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ORIGINAL ARTICLES.

I.—The Rocks of the Volcano of Rhobell Fawr.

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THE conclusions as to the stratigraphical relations of the volcano of Rhobell Fawr, north of Dolgelley, in Wales, which were arrived at by Mr. T. H. Holland and myself,[1] have received kindly recognition from Sir Archibald Geikie in his Presidential Address to the Geological Society of London in 1891;[2] and we may now consider that the great ring of Arenig volcanoes, Cader Idris, the Arans, Arenig Fawr, and Moelwyn, rose upon an area already shattered by sporadic Cambrian outbursts. After again visiting Rhobell Fawr in 1892, in company with Mr. Mervyn Marshall, I feel able to give some account of the rocks that build up that volcano and its outlying fort-like masses.

The area, extending some four miles from north to south and two miles from east to west, is coloured generally as "greenstone" on the map of the Geological Survey, which was published in 1855; but it is probably well known that the mass has in reality a complex structure, including a few dykes and lavas, and immense accumulations of tuff and ash. Mr. Clifton Ward wrote,[3] "The rocks of Rhobell-fawr, with the exception of a few small patches of undoubted greenstone, seem to be mainly of volcanic origin. The greatest thickness of beds exposed in a clearly continuous section, from the base on the south side of the summit, consists of alternations of coarse ash, breccia, and slaggy or scoriaceous breccia, with which are mingled in many parts numerous crystals of hornblende, some of them attaining a very large size." Mr. Ward recognized, particularly on account of the prevalence of hornblende crystals, that the material erupted was "of a slightly different nature to that now forming the widely spread felstone and ash-beds of Arenig and Llandeilo age."

I. The Augite-Aphanites.

There are but scanty representatives of the deep-seated rocks of Rhobell, and most of these have cut through the later ashes. Yet they have a general affinity with the fragmental materials of the

[1] "On the Structure and Stratigraphical Relations of Rhobell Fawr," Geol. Mag. 1890, p. 447.
[2] Quart. Journ. Geol. Soc. vol. xlvii. Proceedings, p. 107.
[3] Mem. Geol. Survey of Great Britain, vol. iii. 2nd edit. p. 58.

mountain, setting aside the hornblende crystals that occur so freely in the tuffs. Augite occurs, as we shall see, as the prevalent ferro-magnesian constituent of the massive rocks and also of the scoriæ.

The augite-aphanites, or dolerites, do not contain olivine, and are the holocrystalline representatives of fairly basic andesites. One of the freshest examples (a third of a mile north-east of the summit of Rhobell Fawr, and across the wall) has a beautiful ophitic structure. The plagioclases, by the test of symmetrical extinctions, prove to be oligoclase, with here and there an albite, and are excellently preserved; but titanic iron ore is freely scattered, and the specific gravity of the mass is 2·89. In the steeply descending enclosed area half a mile south of the summit there is a band of augite-aphanite intersected by abundant veins of compacter material. This mass is more basic, with labradorite and titanic iron ore, and a specific gravity of 2·97. The ophitic structure, so common also in the Cader Idris "greenstones," is again conspicuous; but the later stage of consolidation has been hurried, and the ophitic areas thus lie scattered in a fine-grained groundmass. In fact, it is an unusually striking example of distinct ophitic crystals of augite, which, moreover, are often simply twinned. The included felspars run in from the surrounding groundmass, and hence the ophitic areas were formed *in situ*, and not floated up from a shattered and pre-existing mass.

A third specimen, on the fringe of the area, south-east of Allt-lŵyd farm on the upper Mawddach, is continuously ophitic. Pyrite is developed in it, a characteristic mineral of the whole district.

The intrusive mass to the south of the summit of Moel Cors-y-garnedd is a handsome augite-aphanite with scattered porphyritic pyroxene; its specific gravity is 2·98. It might prove to be another outcrop of the mass that appears in the enclosed area south of Rhobell Fawr.

There are some bosses of compact aphanite, coloured yellow-green by epidote, on the south of the volcano, between the ashes of Bryn Brâs and Garth Fâch; there is a small exposure below the footpath east of the summit of Moel Cors-y-garnedd; and in the valley of the Geirw, between Rhobell Ganol and the north-west spur of Rhobell Fawr, there are three or four places where aphanites come up through the hornblende-ashes or the Lingula Flags. One of these rocks, almost as fine-grained as an andesite, has a specific gravity of 2·98, which is accounted for by the copious development of yellow epidote, one of the commonest minerals in basic igneous rocks throughout N. Wales. These are all the occurrences of undoubtedly holocrystalline rocks with which I am acquainted in this area.

II. The Basaltic Andesites.

There are, however, a number of andesites, some of which are intrusive. They are all somewhat uninteresting to the eye; but they divide themselves on closer examination into augite-andesites of a basaltic character, doubtless once richly dark in colour like those of the Nahe or of Selmeczbánya; and a series of highly felspathic

rocks, on the other hand, which I shall class here as Trachytic Andesites. Probably alteration has deepened the original grey tint of many of the latter, and lightened the blackness of many of the former series, intercalating specks of epodite and chlorite, until the whole group of andesites has become monotonously alike.

Some, however, of the more basic series are heavy and compact, and yellow-green through abundant epidote. One of these, on the summit of the picturesque bluff of Graig Fâch, contains soft dark grey pseudomorphs, which seem under the microscope to be after pyroxene. This suggestion is borne out by several blocks gathered from the tuffs, and by the grey-green andesite of the cliff west-north-west of Ty-mynydd-y-newydd, a rock that looks merely like a baked ash in the field. Under the microscope it shows porphyritic augites here and there; but the majority have been reduced to patches of epidote and chlorite. This rock, one of the lowest on the east flank of the volcano, has a specific gravity of 2·95.

Then, among the hornblende tuffs of Rhobell-y-big, a mass of porphyritic augite-andesite occurs, successfully imitating the compacter tuffs to the naked eye. The augite is here in excellent preservation, and is simply twinned; the felspathic constituent, however, is nearly lost. In the groundmass a number of hexagonal pseudomorphs furnish one of those provoking suggestions of nepheline which seem destined to remain nothing better than suggestions. The examination of early Palæozoic lavas is sometimes more irritating than conclusive.

Hard by, south of the fine crest of Rhobell-y-big, we have a grey-green and almost flinty lava with porphyritic augites, many of them entirely replaced by granular epidote. Those that are preserved show a very marked zonal structure, and the invasion of epidote has attacked them in the outermost zones. This rock has a specific gravity of only 2·83.

A scoriaceous lava, one of very few, on the descent to the road south of the summit of Rhobell Fawr, with its cavities full of chlorite, zeolites, calcite, and chalcedony, is basic enough to be referred to this division of the andesites.

Coming farther south, there is an andesite, rich in epidote, at the north-east end of Bryn Brâs; the porphyritic crystals, soft and dark grey, are mere green pseudomorphs under the microscope, with little epidote granules in a chlorite ground; but their cross-sections in the specimen show them to have once been pyroxene.

So far, hornblende does not seem to be a constituent of the basaltic andesites of Rhobell, though occurring freely in the tuffs. But high up on the north-west spur of the mountain, east of Ty-canol, and west of the hollow of the Geirw, there is a broad exposure of scoriaceous lava which contains abundant hornblendes. In the field Mr. Marshall and myself referred it to the hornblende ashes, but fragments of lava were not apparent in the groundmass. The zoning of the hornblendes was the most pronounced feature; and this, under the microscope, is seen to be connected with their alteration. The lava is an amygdaloidal augite-andesite, the por-

phyritic pyroxenes remaining sufficiently preserved for recognition: but brown hornblendes, 1 cm. or so in length, have been brought up freely with it and form its more obvious porphyritic constituent. As usual, the hot magma has acted on the outer zone of the crystals, and has left only a band of magnetite dots; inside this is a zone in which the colour and pleochroism of the mineral are preserved; and the central area is bleached and fibrous, still retaining enough continuity to show that its extinction agrees with that of the brown zone. Epidote has arisen in this area, and fine needles of almost colourless secondary amphibole penetrate the groundmass of the rock in every direction. The specific gravity of this hornblende-augite-andesite is as high as 2·95.

III. The Trachytic Andesites.

Rhobell Fawr is a complex area of ridges and hollows, stream-cuts, and bolder valleys; and it was not until my third visit that I realized the important part played in the constitution of the volcano by rocks first noted on the extreme east, but having their full development on the passes over to Llanfachreth on the west. These form a series of compact grey rocks resembling phonolites or tephrites in various stages of decay. Coming as I did on this last occasion fresh from the fascinating phonolite domes of N.W. Bohemia, the appearance of these rocks was most attractive, and their detailed study, as usual, disappointing. What felspathoid may have once been present in them, besides the abundant plagioclase, it is now impossible to say. The felspars are largely converted into microcrystalline dusty areas; the porphyritic pyroxenes, preserving their outlines, are often mere patches of calcite. These plagioclastic lavas are unlike the Welsh "felstones" on the one hand, and the heavy basaltic andesites on the other. They have now a pretty uniform specific gravity of 2·75, the more highly silicated eurite of Dduallt, which lies in the Arenig series, giving only 2·60. I have classed these grey rocks of Rhobell together under the Trachytic Andesites, since their common characters, poverty in ferromagnesian constituents and abundance of plagioclase, would certainly carry them into this division.

Wherever I have been able to follow them out, these lavas are intrusive. One of them comes up between ash and slates under Graig Fâch, and has baked the slates beneath it; its specific gravity is 2·74. Another, scoriaceous but intrusive, its hollows filled with chlorite, appears similarly above the slates half a mile to the north north-east of Graig Fâch and south-west of Ty-newydd-y-mynydd. It has a specific gravity of 2·77.

South-west of Graig Fâch, and still at the base of the mountain, we have an intrusion of grey andesite among the slates, which are there well exposed along a steep stream-cut. This mass climbs for some distance towards the greenish ashes of the upper slope, and probably penetrates them, like the rock of Graig Fâch. It contains some pretty pseudomorphs after zoned porphyritic pyroxene.

In the hollow between Moel-Cors-y-garnedd and Rhobell Fawr

another and more felspathic mass occurs, possibly a lava contemporaneous with the ashes round it. Its specific gravity is 2·75.

The great area for these puzzling rocks is, however, the high shoulder traversed by two romantic little passes, the Bwlch Goriwared and the Bwlch Gwyn. The latter spot, especially at sunset, is one of the most charming view-points in North Wales. Where the road from the base of Moel Hafod-Owen begins to rise and go over to Llanfachreth, the trachytic andesites come in intrusively among the slates. One can trace them along Foel Cae-poeth, and pick them up again at the Bwlch itself in a tor-like exposure on Moel-y-Llan. A great amount of calcite has arisen in them, and ferromagnesian minerals are hardly traceable. The specific gravity of the rock near Foel Cae-poeth is as low as 2·70.

On Moel-y-Llan the rock contains abundant small crystals of pyrite, which are now often represented by skeletal remains. Decomposition-products, probably the stable oxide limonite, separated out along planes that, from their angles of intersection, seem to be those of the octahedron; consequently we have now the black casts, as it were, of these cracks alone remaining, with a mere amorphous infilling between their intersections to represent the solid crystal. These dark skeletal meshes are certainly formed of planes, not of intersecting rods; and hence the above explanation seems the true one.

Between the two passes, on the hummocky ridge, the flinty andesite weathers white like the Arenig eurites, and is in every way calculated to deceive the observer. On the high boss just west of the Bwlch Goriwared, the greener and softer character reveals itself when the rock is broken, and it has a specific gravity of 2·76. The pseudomorphs in this place point to hornblende as an original porphyritic constituent, which would mark off this example from all the other trachytic andesites of Rhobell. Skeletons of pyrite occur, recognisable only when compared with those of Moel-y-Llan, since the interstices are in this case coloured a pale chlorite-green.

Then, down under the Coed Cwm-yr-Eglwys, close to Llanfachreth, there is a very fine-grained pyritous rock, with a specific gravity of 2·84, probably belonging to this series; but it is so soft and fissile that it has been collected only to be laid aside again. Enough unsatisfactory material has already been described.

IV. The Tuffs and Ashes.

The great remaining masses of the Rhobell Fawr volcano are tuffs and ashes, the former containing in places blocks some 20 cm. across; but the general character, despite the description in the Survey Memoir, is fine-grained in comparison with those of Snowdon or Cader Idris.

On the south the ashes are in general less coarse, and take up the cleavage of the district, as may be noticed in Garth Fâch. Near the summit of Moel Cors-y-garnedd they have been laid out in water, and contain sand-grains and argillaceous bands, passing in places into the grit that caps the hill. Similarly the ashes are gritty

under the corresponding bed on Rhobell Fawr,[1] while the grit ("Garth Grit") itself contains pebbles of lava washed down into it.

Coarser tuffs, with unmistakable scoriæ, may be seen from the tumbled moorland below Cerniau, and across the Pabi, away to the crest of Rhobell Fawr. A section cut from one of these scoriæ shows the felspar replaced entirely by epidote and chlorite, and the ferromagnesian constituent represented by mere black skeletons. Its specific gravity is 2·88. In general the tuff has a *purple* tint, and the scoriæ weather away more easily than the tough interstitial ash, which is quite contrary to one's experience on more recent cones. Here the whole mass has been so compressed, consolidated, and mineralized, that the looseness of the ash or the massiveness of the ejected blocks no longer exerts an influence, and the amount of loss by denudation depends mainly on compactness. The vesicular blocks of lava are eaten away, and the surrounding volcanic dust stands out as a meshwork of fine ribs.

The highest rock on Moel Cors-y-garnedd, even above the grit, is a grey highly felspathic ash, with a specific gravity of 2·70. The plagioclases are well preserved, and this bed points to the intrusion and eruption of the trachytic andesites during the last phase of activity on Rhobell Fawr. The slate ash at the base of the Arenig series east of Ty-newydd-y-mynydd is also felspathic, like many on Cader Idris; but there are fragments of glassy lavas in it unlike anything on Rhobell, and it probably marks the next period of activity from a vent further to the east.

There is also ash on Rhobell Fawr above the ring-like exposure of the grit; below, especially to the north and south, we descend over magnificent developments of Hornblende-Tuff.

This rock has at times been styled a "Hornblende-Porphyry"; but the microscope exposes its typically fragmental character. In the wide moorland from which Rhobell Ganol, Moel Gron, and the bold peak of Rhobell-y-big rise, hornblende-tuffs and ashes are everywhere conspicuous, until we find their most striking representatives in Rhobell-y-big itself. A little to the east, down on the nearest tributary of the Mawddach, these deposits may be seen in contact with fossiliferous Lingula Flags. On the whole, they form a basal feature of the volcano, and their coarseness at Rhobell-y-big suggests a local centre of eruption north of the main crater. Possibly the andesite with porphyritic zoned hornblendes, previously described from the N.W. spur of Rhobell, may have acquired its hornblende from these tuffs, which were traversed by it in its ascent.

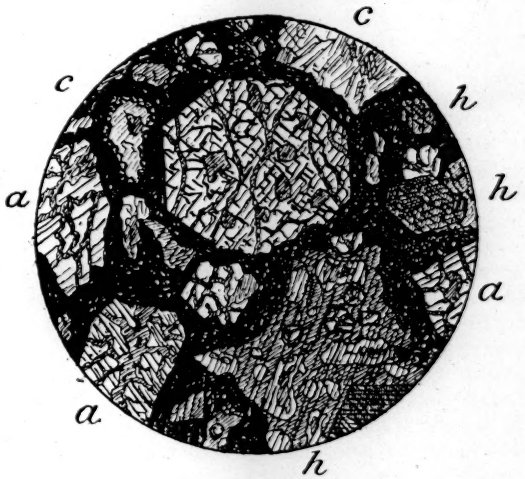
The scoriæ and lumps of lava in the hornblende-tuffs are merely basaltic and trachytic andesites with altered pyroxene, resembling those described above as massive rocks. An ejected block from Rhobell Ganol, containing much epidote, has a specific gravity of 2·96. Small irregular brown hornblendes occur in some of the fragments on the south of Rhobell Fawr; but I find in these fragments as a whole a repetition of the lavas of the area, and the

[1] See Cole and Holland, "Structure of Rhobell Fawr," Geol. Mag. 1890, pp. 448 and 452.

conspicuous crystals of hornblende lie in the ground between them, and are derived from some deep-seated source.

The conditions that give rise to amphibole being hydrothermal, rather than those that prevail in the ordinary cooling of a lava, it is not necessary to suppose that in this instance an amphibolite has been shattered by the explosions and its remains mingled with the normal lavas; we may conceive that the brown hornblende developed porphyritically as a deep-seated constituent from the local magma, but that augite took its place when the same magma consolidated nearer the surface. In that case, considering the enormous abundance of the crystals, it is remarkable that we so seldom find them included by flotation in the lavas from which they are supposed to have developed. I am inclined to think that a rock rich in amphibole did actually exist beneath this area, perhaps a true amphibolite, and that it was traversed and broken up by the eruptions of basaltic andesite. These eruptions became less uniform in character towards the close of activity, giving us, particularly on the west, the grey trachytic andesites, and in places the handsome ophitic aphanites, which are often of a more basic character.

The amphibole of the tuffs is accompanied, however, by pyroxene, which is often quite as abundant. The two minerals are found grouped together, and evidently once formed part of the same rock.



Section of Ash from Summit of Rhobell-y-big, Merionethshire, × 5.

a, Augite, pale yellowish, with cracks and ovoid areas filled with green decomposition-products. A large cross-section is conspicuous above.

h, Hornblende, rich brown. The large lower one includes small granular pyroxene, but also has several almost colourless areas, across which the cleavage runs, and which may result from the substitution of secondary amphibole for some included mineral.

c, Hollows filled with chlorite, the right-hand one containing small secondary amphibole, and the left-hand one a border of yellow epidote.

Sometimes brown hornblende has developed paramorphically and sporadically within a large pale pyroxene; but much of the hornblende looks original and distinct. These crystals remind one so strongly of the Peridotites of Schriesheim or Loch Scye that one expects to find included olivine; but only a few green ovoid pseudomorphs in one specimen give direct countenance to this idea. The crystals are much torn and shattered; the cracks of the pyroxene have been filled up by chlorite, or by a very finely divided granular material; the hornblende has, however, been restored by a pale amphibole in optical continuity.[1] The hornblende crystals have also in places been extended by secondary amphibole, in flame-like protrusions, into the surrounding ash, and a number of actinolitic needles run through the altered groundmass.

In some of the hornblende crystals there are suspicious ovoid areas of a very pale green tint, across which the mineral is optically continuous. These may represent places from which olivine has been entirely removed, the gap being steadily filled in by the familiar pale secondary amphibole. A comparison of this structure with that of the olivine-bearing rocks of Menheniot, Schriesheim, etc., makes the suggestion seem at any rate not extravagant.

V. The Grits.

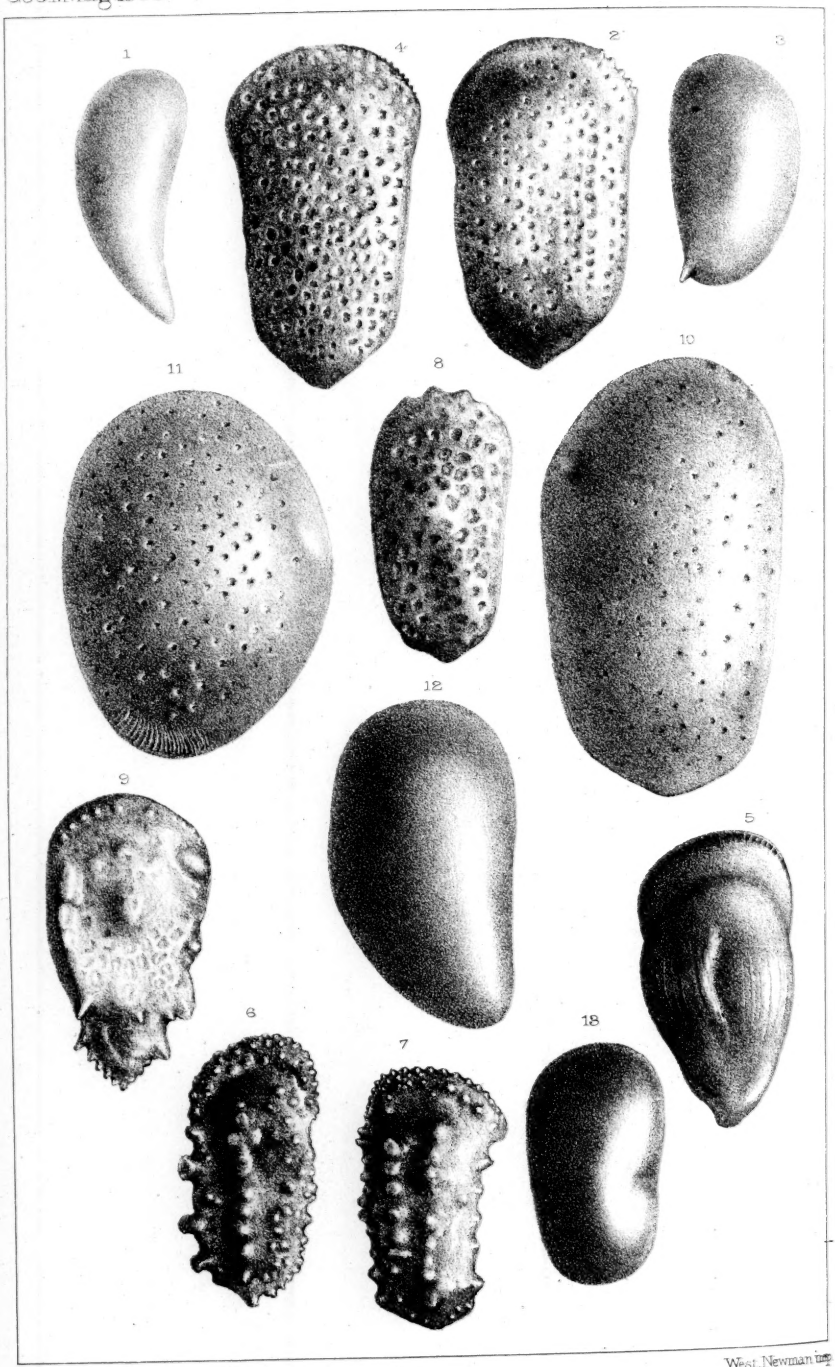
The detailed examination of the grit-bands proves their aqueous origin as clearly as is done by the larger pebbles in the field. It is rather difficult to know where all the quartz-grains came from—certainly not from any disintegration of the volcanic rocks of Rhobell. A few pebbles of compressed quartzite seem to point to the Harlech Grits as a source of origin, or even to the pre-Cambrian rocks from which those masses were derived.[2] The pebbles of lava are probably local, resembling the trachytic andesite series; and the abundant isolated plagioclases are additional evidence that the more felspathic eruptions occurred at the close of the volcanic action.

The most interesting constituents of the grit-beds are the ovoid black and grey bodies that show a concentric structure on weathering. Mr. Holland and myself[3] referred this structure to contraction; but microscopic sections show that it is in reality fundamental. These bodies, have, in fact, a rippled concentric mode of growth, and their layers appear transparent brown, colourless, or faintly green. Some of them include angular grains of quartz-sand, which show that they have arisen somehow in a sedimentary rock. On boiling the dark mass in hydrochloric acid, the greater part dissolves with effervescence, colouring the acid intensely yellow. A fine residue of quartz-sand, mica, and minute argillaceous particles, alone remains. These curious bodies may be referred, then, to the beds of pisolitic iron ore which were forming on the spot at the opening of the Arenig epoch; and they are, in fact, isolated concretions, often of large size, rolled out from those deposits. The best examples of them

[1] *Cf.* Marshall Hall, Geol. Mag. 1889, p. 480.

[2] *Cf.* Jennings and Williams, "On Manod and the Moelwyns," Quart. Journ. Geol. Soc. vol. xlvii. p. 373.

[3] *Loc. cit.* p. 449.



C.D.S. & F.C. del.
Woodward lith.

West, Newman imp.

that I possess are pale grey in colour, and occurred in a loose block of grit low down in the wood near Gell Fachreth. The faulting here, which brings down the Arenig ashes, may also have lowered the grit of Moel Cors-y-garnedd.

A series of sections from typical pisolitic and oolitic ironstones of N. Wales has facilitated this comparison; but the bodies in the grits of Rhobell evidently consist largely of ferrous carbonate, and have not undergone the reduction to magnetite from which most of the oolitic ironstone beds have suffered. This is the only evidence I possess of the occurrence of a ferrous carbonate stage in these deposits, though it has previously been hinted at [1] during a discussion of their mode of origin.

After assigning these concentric bodies to the layers of Arenig ironstone, it is strong support to find that Messrs. Jennings and Williams [2] have observed pebbles derived from the oolitic ironstone in a grit of the Arenig series in the Moelwyn area.

II.—On the Ostracoda of the Gault at Folkestone.

By Frederick Chapman, F.R.M.S.,
and C. Davies Sherborn, F.G.S.

(PLATE XIV.)

SINCE the year 1885 the various zones of the Gault at Folkestone have been systematically examined by one of us for the purpose of recording the Foraminiferal fauna of that deposit; the report upon which is now being published in the Journal of the Royal Microscopical Society.

At the same time the Ostracodal valves were isolated from the washings with the view of a similar report being made upon them; and it is thought that the publication of the results will be of some interest, in showing the distribution and relative abundance of these minute animals through the various deposits laid down in the Gault sea of that locality.

The extreme profusion of certain forms in particular beds is remarkable, and this segregation of species is often referable to the lithological differences met with in the various strata. (The nature of the deposits in the various zones and horizons is described in detail in the publication before mentioned.) [3] The slight connecting links of the Gault with the Jurassic Ostracoda on the one hand, and with those of Tertiary age on the other, have an additional palæontological interest.

But few new forms were met with, and this is strong testimony to the lifelong care bestowed upon the Cretaceous Ostracoda as a whole by Professor T. Rupert Jones. The results of his labours are embodied in a supplementary monograph of the Cretaceous Entomostraca of England and Ireland (Pal. Soc. 1890), of which we have

[1] Cole and Jennings, "Northern Slopes of Cader Idris," Quart. Journ. Geol. Soc. vol. xlv. p. 427.

[2] *Loc. cit.* p. 374.

[3] F. Chapman, The Foraminifera of the Gault of Folkestone, part i., Journ. Roy. Micro. Soc. 1891, pp. 566–572.

ZONAL DISTRIBUTION OF THE OSTRACODA IN THE GAULT AT FOLKESTONE.

	Zone i.		Zone ii.			Zone iii.	Zone iv.	Zone v.	Zone vi.	Zone vii.	Zone viii.	Zone ix.	Zone x.	Zone xi.									Mr. F. G. Price's Collection.	Godstone (Chapman & Sherborn).	C. Moore, Meux's well.
	Greensand Seam.	5 ft. from base.	Band of Crushed Ammonites	11 ft. from base.	13 feet from base.									55 ft. from the top.	50 ft.	45 ft.	40 ft.	35 ft.	30 ft.	25 ft.	20 ft.	12 ft.	6 ft.			
CYPRIDIDÆ.																									
Paracypris gracilis, Bosq.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*
,, *siliqua*, J. & H. ...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	3	2	1	2	1	12	...	2				
Pontocypris trigonalis, J. & H. ...	...	...	...	...	...	...	...	...	...	...	...	...	1	5	...	1	2	...	...	...	1					
,, *triquetra*, Jones	...	...	...	...	...	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...	...	1	2			
,, *Bosquetiana*, J & H.	1	...	...	3	1	...	...	2	3	...	2	1	2	1	3											
,, *attenuata*, Reuss. ...	..	...	...	...	...	...	...	...	...	...	...	3	2	...	2											
Bairdia subdeltoidea, Mün.... ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	18	1	9	...	*	
,, *Harrisiana*, Jones ...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	1	2	10	...	2	...	...	1	1			
Macrocypris Muensteriana, J. & H.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*		*
Bythocypris Reussiana, J. & H. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	
,, *silicula*, Jones	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1				
,, ,, var. *minor*, J. & H.	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	..	...	1	1						
CYTHERIDÆ.																										
Cythere Harrisiana, Jones	...	10	...	3	...	25	5	30	9	50	10	110	16	14	6	60	11	1	...	2	...	...	...	*	*	
,, ,, var. *setosa*, J. & H.	...	...	...	...	...	1	...	2	...	...	...	...	8	2	2	2	1	...	...	...	...	...	...	...	*	
,, ,, var. *reticosa*, J. & H.	...	...	...	...	...	6	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	
,, *lineatopunctata*, C. & S.	..	...	...	...	...	...	1																			
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,, *spinifera*, C. & S.	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	2	1	1	1	1						
Cythereis triplicata, Röm.	...	25	1	1	2	2	1	6	...	6	1	...	5	1	1	3	1	10	10	12	4	16	14	*	*	
,, ,, var. *lineata*, C. & S.	..	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1				
,, *auriculata*, Corn.	1	6	...	4	1	13	3	14	3	11	20	11	16	13	8	6	1	2	1	1	16	2	1	...	*	
,, *quadrilatera*, Röm. ...	...	8	...	...	...	2	...	3	1	1	1	10	220	50	500	12	3	...	...	...	...	...	5	*	*	*
,, *ornatissima*, Reuss. ...	...	...	11	...	...	10	60	...	...	...	1	...	100	...	...	...	...	...	...	1	17	5	2	*	*	*

,, *quadrilatera*, Röm. ...	...	8	...	...	...	2	...	3	1	1	1	10	220	50	500	12	3	...	...	...	...	...	5	*	*	*						
,, *ornatissima*, Reuss. ...	...	...	11	...	...	10	60	...	...	...	1	...	100	...	...	...	...	...	...	1	17	5	2	*	*	*						
C. ornatissima, var. *rudispinata*, C. & S.	...	2	...	3	...	...	...	1	...	...	...	...	...	2																		
,, ,, var. *paupera*, J. & H.	...	...	...	...	...	...	...	...	...	1																						
,, ,, var. *nuda*, J. & H.	...	...	...	1	...	...	...	...	...	...	...	...	...	...	5	100	50	10	10	20	...	...	...	*								
,, ,, var. *reticulata*, J. & H.	...	5	...	2	...	3	6	8	1	...	3	3	30	4	8	5	3	3	4	12	14	3	7	...	*							
,, ,, var. *stricta*, J. & H.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3													
,, *excavata*, C. & S.	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	3	1									
,, *Wrightii*, J. & H., var. *aculeata*, C. & S. ...	...	1	...	...	...	2																										
,, *Lonsdaleana*, Jones ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100																	
,, *vallata*, Jones	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1											
Cytheridea perforata, Röm. ...	2	40	60	4	9	16	100	2	13	7	1	3	18	1	9	4	10	11	23	60	2	13	3	*	*	*						
,, ,, var. *insignis*, Jones ...	1	...	2	...	1	2	2	3	...	...	2	1	3	1																		
,, *rotundata*, C. & S. ...	...	1																														
Pseudocythere ? simplex, J. & H.	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1																
Cytherura appendiculata, Jones ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*								
Cytheropteron concentricum, Reuss	...	60	2	4	...	40	100	11	9	7	1	11	550	4	4	15	13	11	1	...	5	8	10	*	...	*						
,, *alatum*, Bosq., var. *cornuta*, Bosq.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1											
,, *umbonatum*, Will.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1									
,, ,, var. *longispinata*, J. & H.	...	...	...	...	...	3	1	1																								
,, *Sherborni*, J. & H.[1] ...																																
,, *Folkestoniense*, C. & S. ...	...	1																														
CYTHERELLIDÆ.																																
Cytherella ovata, Röm.	...	4	1	2	4	9	3	8	18	7	2	11	550	3	110	60	4	10	50	50	4	5	63	*	*	*						
,, *Muensteri*, Röm.	...	4	1	3	4	16	25	25	14	1	7	2	10	2	5	1	1	2	...	5	1	8	3	*	*	*						
,, *subreniformis*, J. & H. ...	...	...	...	...	...	...	...	...	1																							
,, *Williamsoniana*, Jones ...	...	...	...	...	...	...	...	4	...	...	1	...	20	...	50	60	50	...	12	1	2	1	...	*	*	*						
,, ,, var. *stricta*, J. & H.	...	...	...	...	...	...	...	1	...	...	1	3	50	5	2	3	1	1	...	...	...	...	1	...	*							
,, ,, var. *granulosa*, Jones	...	...	...	...	...	...	...	2	...	...	...	...	...	...	1	50	...	...	10													
,, ,, var. *Chapmani*, J. & H.	...	...	...	...	...	...	1	12	...	1	1	...	...	...	...	2	...	...	...	...	...	...	...	...	*							
,, *Beyrichi*, Reuss.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*						
POLYCOPIDÆ.																																
Polycope, sp....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*						

[1] Recorded by Jones in error on p. 53, Mon. Cret. Entom. 1890.

made full use, while our special thanks are due to him for examining our material and verifying our determinations.

In the appended Distribution Table the numbers in the general columns refer to the approximate number of specimens found in the whole of the residual material after washing from 4 to 6 cubic inches of the rock.

The forms which appear to be new we now proceed to describe; and give (on pp. 346 and 347) a table showing at a glance the zonal distribution of the forms found in the Gault, and additional forms not found by us, but recorded elsewhere.

CYTHERE ? SPINIFERA, sp. nov. Pl. XIV. Fig. 3.

A smooth carapace, strongly arched on the dorsal, straight on the ventral side; with a projecting spine on the ventral margin at the hinder end. Hinge-line a simple flange.

Distribution.—Eight valves, from Zone x. and Zone xi., at 50 feet, 45 feet, 40 feet, 35 feet, 30 feet, and 25 feet from the top of the Gault at Folkestone.

CYTHERE LINEATOPUNCTATA, sp. nov. Pl. XIV. Fig. 4.

A strong carapace, much swollen at the ventral margin and overhanging; with coarse square punctations arranged in somewhat parallel lines. A central ridge, not very strongly developed, runs down the length of the shell.

Distribution.—One valve only, from Zone iv. of the Folkestone Gault.

CYTHEREIS TRIPLICATA, Röm. var. *lineata*, var. nov. Pl. XIV. Fig. 5.

These specimens possess the general form of *C. triplicata*, but have each of the lobes or ridges delicately ornamented with three or four longitudinal raised striæ.

Distribution—Two specimens, one with united valves from Zone i. 5 feet from the base, and the other from Zone xi., 12 feet from the top of the Folkestone Gault.

CYTHEREIS RUDISPINATA, sp. nov. Pl. XIV. Figs. 6, 7.

Closely allied to the many forms of Cythereis from the Cretaceous formation, and differing therefrom by having the three parallel ridges of curious and characteristic spines, which are spreading and flat at the apex, and in some specimens assuming large and pronounced mushroom-shaped prominences.

Distribution.—Eight valves from Zones i. (5 feet from base); ii. (11 feet from base); v., and xi. (55 feet from the top) of the Folkestone Gault.

CYTHEREIS EXCAVATA, sp. nov. Pl. XIV. Fig. 8.

Subquadrate, with an irregular front, just below which is a fenestrated much-raised ridge. The whole surface coarsely reticulate; rising up towards the hinder part of the carapace, standing away from the true margins, and terminating about seven-eighths from the front in a sharply defined edge.

Distribution.—One valve only, from Zone ix. of the Gault of Folkestone.

Cythereis Wrightii, J. and H., var. *aculeata*, var. nov. Pl. XIV. Fig. 9.

The general characters of this form are similar to the type species; but the rounded processes seen in *C. Wrightii* are produced in this form into spikes and prickles. The front edge of the shell is very thin; the hinder end is produced into a long spike, and the margin in that region is strongly aculeate.

Distribution.—One valve from Zone i., 5 feet from the base; and two from Zone iii., of the Gault of Folkestone.

Cytheridea rotundata, sp. nov. Pl. XIV. Fig. 11.

Valve of a subspherical form, with very coarse punctations showing as pimples on the inner surface. Hinge-line, a bar with a pitted socket at each end.

Distribution.—One valve only from Zone i., 5 feet above the base of the Gault at Folkestone.

Cytheropteron Folkestoniense, sp. nov. Pl. XIV. Fig. 13.

Valve of an oblong shape and with the mid-dorsal sulcus well marked. The central area of the valve tolerably flat, and the slope to the ventral and dorsal margins steep. There is also a dorsal flange. The posterior portion of the carapace slightly higher than the anterior. Surface polished.

Distribution.—One valve only, from Zone i., 5 feet from the base of the Folkestone Gault.

EXPLANATION OF PLATE XIV.

Fig. 1.—*Pontocypris attenuata*, Reuss, right valve, × 50.
,, 2.—*Cythere Koninckiana*, Bosquet, left valve, × 50.
,, 3.— ,, ? *spinifera*, sp. nov., right valve, × 50.
,, 4.— ,, *lineatopunctata*, sp. nov., right valve, × 50.
,, 5.—*Cythereis triplicata*, Röm., var. *lineata*, var. nov., left valve, × 50.
,, 6.— ,, *rudispinata*, sp. nov., right valve, × 50.
,, 7.— ,, *rudispinata*, sp. nov., left valve, × 50.
,, 8.— ,, *excavata*, sp. nov., left valve, × 50.
,, 9.— ,, *Wrightii*, J. and H., var. *aculeata*, var. nov., left valve, × 50.
,, 10.—*Cytheridea perforata*, Röm., var. *insignis* (Jones), right valve, × 50.
,, 11.— ,, *rotundata*, sp. nov., left valve, × 50.
,, 12.—*Pseudocythere ? simplex*, J. and H., right valve, × 50.
,, 13.—*Cytheropteron Folkestoniense*, sp. nov., left valve, × 50.

III.—Glacier Observation, more especially Colonial.

By Captain Marshall Hall, F.G.S., F.C.S.;
Member of the Alpine Club.

FOR many years the writer has wished for the means to bring about some uniform system of glacier observation, and more especially the collection of data respecting ice-movements in British Colonies, and territories under British influence. When we think of our mountains in the Dominion of Canada and in New Zealand, and the vast ranges of the Himalayas (these last we shall before long hear about from Mr. Conway), it seems a great pity that such promising fields should not be adequately worked. In an article in the Alpine Journal, for February, 1891, the writer sketched a plan of operation; and in the same Journal, for February, 1893, asked for a committee to communicate with such Colonial Governments as could take part.

Recently the Alpine Club has formed such sub-committee, and is about to appeal to the authorities. A Memorandum drawn up by the President, Mr. Douglas W. Freshfield, and which we subjoin, will be sent with each letter, in the hope that officers, surveyors, and explorers will be induced to give us their valuable aid.

The Memorandum in question only deals with the more pressing requirements as to ice-movements, etc., as it was not wished, in beating up recruits, to alarm such by too formidable an amount of work.

With regard to the suggestion in its last paragraph it will be as well to caution surveyors that, if a row of stakes is made use of, they should be of good size and planted deeply; surface ablation is rapid in hot weather, and Herr Escher von der Linth, having, on July 8, 1841, inserted stakes in holes 3 feet deep on the Aletsch Glacier, found, on August 16 (39 days later), all the stakes fallen, and no trace of the holes. Where available, rocks on the glacier surface, even though not likely to be in a straight line, are the best for surveying purposes. Even they have a bad habit of tumbling into crevasses! Mr. Brodrick, of the New Zealand Alpine Club, is early in the field, having determined the position of a considerable number of carried rocks near the lower end of the Mueller Glacier, and written an able account of ice-motion in the southern New Zealand Alps.

Readers of the Geological Magazine are little likely to take alarm if we mention a few additional points upon which facts would be of value, amongst others, some more especially in relation to the recently revived discussion of the part borne by glacier erosion in the formation of lakes. During sundry seasons the writer spent much time, without success, in attempts to find lakes indubitably produced by glacier action. Nevertheless, other men familiar with the ice-world may be more fortunate, and it is only just to distinguished supporters of the Ramsay theory that we should use our best endeavours to provide them with evidence.

We never remember to have seen terminal moraines of importance which are not, or have not been, cut through by the issuing torrent. In the case of the Mattmark See, in the Saas district, the lake was dammed back by the *lateral* moraine of the Alalin glacier, which, within the writer's memory, traversed the valley nearly at a right angle; but the glacier has retreated, and ten years ago the valley was so silted up that the lake was little more than a shallow pond.

The evidence as to the pace of the same glacier at different heights is none too copious, whilst the motion of the névé and of the snow masses which feed the ice is very little known. We look upon this last as almost new ground to break.

Professor F. A. Forel has recently caused lead plates, engraved with date, etc., to be buried near the summit of Mont Blanc.

The comparative amount of rocks and of detritus resting upon glaciers, and of that which has found its way beneath, and the amount removed by torrents from beneath ice, are difficult points which we recommend to good calculators more especially. Dr. A. R. Wallace especially draws the writer's attention to this.

How far are terminal made out of ground moraines?

The more adventurous will possibly not object to some unavoidable risk in explorations under the ice! Professor F. A. Forel has made many such trips. This leads us to expostulate with those who tell us that ancient glaciers were so enormous that for want of weight and pressure we cannot expect to find instances of lake-making in the puny glaciers of our day. The writer can scarcely imagine, having regard to the historical advance and retreat of ice, that such action can never be seen, similar in kind though not in degree. In fact this appears so palpable that in entire absence of existing work things would go hard with theories of former exploits.

We could multiply points of investigation almost *ad infinitum*. Here is plenty to do for many shrewd travellers. Nothing but personal experience in the higher mountains, where alone we can meet with ice masses, will avail to advance our stock of knowledge, and the writer can say that, although he has been a scrambler since the year 1848, he never remembers spending even a few days in the upper world without observing some phenomenon not previously impressed upon him, even if seen by him before.

Perhaps, after lapse of time, the comparative history of glacier movement in different latitudes and hemispheres may throw some light upon the question of periodicity, secular and other. Suggestions and reports, whether of much or little work, will be thankfully received either by the Hon. Secretary of the Alpine Club, 8, St. Martin's Place, Trafalgar Square, W.C., or by the writer, addressed to him, Easterton Lodge, Parkstone, Dorset.

Perhaps, as the next Congress of Geologists is to meet in Switzerland next year, some arrangements may then and there be come to, by which a chain of connection may for the future exist between different countries. Prince Roland Bonaparte undertakes the history of French Glaciers, except those of Mont Blanc, which Prof. F. A. Forel still takes in hand, as bound up with those of Canton Valais. How much we owe to his untiring enthusiasm!

Since writing the above, Professor Forel's capital monograph "Le Leman" has reached us.

Incidentally to the origin of the lake he gives much and valuable information as to the habits of glaciers.

This, only the first of three volumes, requires a notice of good length, to which we fain hope the Editor will turn his attention in due time.

"MEMORANDUM.

"The recent movements of glaciers may be noted by the following signs:—

"When the ice is advancing the glaciers generally have a more convex outline, the icefalls are more broken into towers and spires, and piles of fresh rubbish are found shot over the grass of the lower moraines. Moraines which have been comparatively recently deposited by advancing ice are disturbed, show cracks, and are obviously being pushed forward or aside by the glacier.

"When the ice is in retreat, the marks of its further recent extension are seen fringing the glacier both at the ends and sides in their lower portions, the glacier fails to fill its former bed, and bare stony tracts, often interspersed with pools or lakelets, lie between the end of the glacier and the mounds of recent terminal moraines.

"Where a glacier has retreated to any considerable extent, careful observations of the form of its bed are of value. What is the nature of the rock surfaces exposed—convex or concave; are they rubbed smooth on their leesides; how far have the contours of the cliffs or slopes, or the sides of any gorge, been modified where they have been subjected to ice-friction? Is there any evidence that the ice has flowed over large boulders, or loose soils, such as gravel, without disturbing them? How has it affected rocks of different hardness, for instance, veins of quartz in a less hard rock? Generally, do the appearances indicate that the glacier has excavated, or only abraded and polished its bed; that it has scooped out new rock-basins, or only cleaned out, scratched, and preserved from filling up by alluvial deposits or earthslips, existing basins? What is the general character of the valley bottom and slopes above and below the most conspicuous ancient moraines?

"The depth of mountain lakes and the position of the point of greatest depth should be ascertained wherever possible. The marginal rock structure of lake basins, particularly near their outlet, is of much importance with a view to ascertaining whether they are true rock basins, or whether they are reservoirs formed by ancient moraines, earthslips, or alluvial deposits.

"The traveller or surveyor should, if possible, paint a mark and date on any conspicuous rock *in situ* parallel with the termination of the glacier at the time of his visit, marking the distance in yards of the ice from it. The next visitor will then be able to measure the movement that has taken place since his predecessor's visit. Leaving out of question elaborate trigonometrical methods, such, for instance, as have been carried out on the Rhone Glacier in Switzerland, the following plan gives very valuable results, and demands no other instruments than a small jar of paint, a brush, a measuring tape, and a pocket compass. To ascertain the recent retreat of a glacier, measure the distance from the end of the ice in front of the longitudinal axis of the glacier to the most advanced terminal moraine, where vegetation first shows itself. The bare ground recently left by glaciers is easily recognisable. The diminution of volume is best measured by ascertaining the height of bare soil left on the sides of the lateral moraines in the portion of the glacier within the zone of vegetation. All photographic representations of the glacier end, and of the ground which has been freed from the glacier ice, are of great value. Those will be of most service that show the position of the glacier-snout with relation to some conspicuous rock or other feature in the local scenery. Each photograph should be dated, and the bearings and distance of the camera with reference to any such feature accurately noted.

"It is very important to investigate the state of various glaciers

as regards advance or retreat. Neighbouring glaciers often furnish very different results in this respect, owing to the fact that steep glaciers anticipate in their oscillations those the beds of which are less inclined. To ascertain the oscillations of glaciers, it is necessary to fix the actual position of the ice-snout at the end of the glacier with the greatest accuracy. Two methods can be employed for this purpose, either of which may be selected according to circumstances.

"Paint some signs on large boulders, not too far from the end of the glacier, and measure their distance from it by a tape (Richter's system), or build a low wall of stones of a few yards in length, and, say 15 to 20 inches in height, some distance from the ice-end, and measure this distance (Gosset's system). It is to be recommended that the stones of these walls should also be painted. If the traveller himself returns after some interval—even after only two or three weeks—he will be able to judge of the movement of the glacier, and he will have laid down a basis for future observations by future travellers.

"One of the results most to be desired is an exact knowledge of the dates:

I. Of the maximum extension of the ice.
II. Of the commencement of retreat.
III. Of the minimum.
IV. Of the commencement of fresh increase.

"In dealing with a mountain group, therefore, the traveller should note (where he can get the information as to the past) the date of the commencement of the actual movement of *each glacier*, and in all cases whether the ice is in advance, or retreat, or stationary. Of course the rate of forward movement, or velocity of the ice, and the oscillations in the extension of the ice must be kept carefully distinct.

"Should time and circumstances permit, a series of observations of the velocity of the ice is of value. These may be made after Tyndall's method, by planting a line of sticks across the glacier, or by painting marks on boulders, the position of which relatively to ascertained points on the mountain-side has been accurately fixed. The size of the glacier, that is, the area of its basin and its length, as well as the slope of its bed above, as well as at the point measured, should be noted. The rate of movement of the ice appears to be connected both with the volume of the glacier and the inclination of its bed."

IV.—The True Horizon of the Mammoth, Etc.: Being a Reply to Mr. Mark Stirrup, F.G.S.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

THE very great importance of the issues involved if we are to make any definite progress in the study of the later deposits must be my excuse for this reply to Mr. Stirrup's letter. He says that the only available material for discussing the results of the expedition of Toll and Bunge to the Siberian islands is an

abstract published by Schmidt some months ago. In this he is surely mistaken. A considerable volume giving detailed information about the expedition has been published for some years in the "Beiträge zur Kenntniss d. Russ Reiches," while more than three years ago an elaborate memoir on the geological and palæontological results of the expedition was read before the St. Petersburg Academy, which has since been translated into German and published in a large quarto. The author of this memoir, Tscherski, is an authority of the first rank upon the geology of Eastern Siberia. Since 1873 he has devoted many years to a personal examination of that little known area, and is probably better qualified to give a sound opinion upon some critical questions regarding it than anybody living.

As to the former existence of a so-called Glacial Period in Siberia he is most emphatic. Krapotkin claimed to have found relics of a widespread glaciation in the mountains of Eastern Siberia, while Czekanovski professed to find similar traces in the Sayanian Mountains. Tscherski absolutely contests this, and declares that in the Mountains of Eastern Siberia there are only traces, and these very slight ones, of individual local glaciers. He says that the supposed scratched blocks from the bed of the River Yenissei near the foot of the Sayanian Mountains, and which are preserved in the Museum of the Imperial Academy of St. Petersburg and in the Museum at Minussinsk, are merely examples of weathering and were so accepted by the geologists who examined them at St. Petersburg. He says that with the exception of a small area west of the Baikal, there are not to be found on the meridian of that sea, nor in the high plateau behind it, including the so-called Apple Range, any indications of the former existence of glaciers. It will thus be seen that the position I argued for, and which I believe is accepted by such an extreme advocate of glacial views as Mr. James Geikie, that there are no traces of a so-called glacial age in Siberia, is fully sustained by the latest and best information on the subject, and that the observations of Von Cotta in the Altai Mountains, and of Nordenskiold along the Polar Sea, are fully borne out by the observations of Tscherski in Eastern Siberia.

This being so, it is not surprising that the latter writer should add that hitherto no traces of so-called inter-Glacial beds have occurred in Siberia nor, he says, in the greater part of European Russia.

I am still at a loss to know upon what evidence and what authority Mr. Stirrup classes the rolled gravels underlying the Mammoth beds in Siberia as glacial deposits. I know of no evidence to support such a contention.

Turning to another side of our discussion, namely, the true horizon of the Mammoth, I should like to quote a statement of Tscherski, in which he refers to the well-known famous skeleton of a Mammoth found at Troizkoya, near Moscow, and which he says lay distinctly in a marine *pre-Glacial bed*. He refers to the section given by Nikitin in vol. ii. of the Memoires du Comité Géologique. He also refers to the deposit of Pleistocene animals discovered in 1878 in the

government of Smolensko by Professor Dokutschayef, and which he says lay in a similar deposit. Its discoverer attributed it, apparently on *a priori* grounds, to a post-Glacial age, but this view is contested and disposed of by Tscherski, who is supported by Nikitin (see the discussion in the Memoirs of the St. Petersburg Academy, vol. 40, p. 474). This shows how the case for the post-Glacial existence of the Mammoth is everywhere crumbling away. I must, in conclusion, refer shortly to Mr. Stirrup's quotations from Favre in regard to the age of the Mammoth in Savoy, etc. He seems to me to have entirely misapprehended the views of that geologist. There is not, so far as I know, any question among French geologists in regard to the meaning of the term "Alluvion Ancienne," which was first used, I believe, by Necker, in 1841, when he separated the so-called diluvial beds near Geneva into two horizons, the lower one of which he called Alluvion Ancienne, and the upper one "terrain diluvian cateclystique." Since his time the meaning of the term "Alluvion Ancienne" has remained fixed and always connotes a pre-Glacial and not a post-Glacial deposit, and Favre retained this connotation when in 1862 he altered Necker's "diluvium cataclystique" into "terrain glacière." Favre, like all other French geologists, treats this Alluvion Ancienne as pre-Glacial.

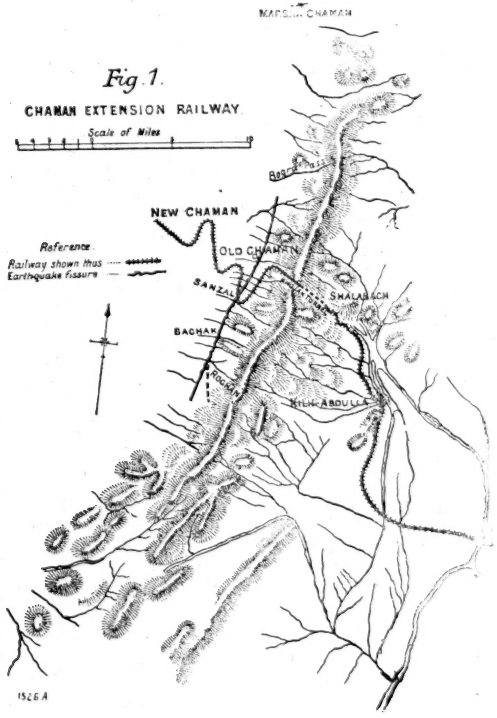
What there is a difficulty about is, not as to the horizon of the Alluvion Ancienne, but as to the age of the so-called "Alluvion de terraces," which Favre separated from the other two diluvial deposits, and which he no doubt says does overlie his "terrain glacière." Now the age of these terrace-gravels, like the age of the brick-earths of the Thames Valley, has been disputed. I believe there is no evidence of superposition, and the question has been decided on *a priori* grounds, which, I venture to think, are worthless in such a discussion. The contents and the character of these terraces seem to me distinctly to point to their being of the same age as the Alluvion Ancienne of the valleys, and to be, therefore, pre-Glacial, in the sense in which that word is generally used, and not Post-Glacial. Favre mentions three instances, and three only, as far as I know of the occurrence in these terrace-gravels of remains of Pleistocene mammals; in two instances remains of the Mammoth and in the other of the Reindeer. May I add that in regard to the most famous Pleistocene deposits of Savoy, namely, the lignites of Sonnaz, they distinctly underlie glacial deposits, while Favre himself says that no glacial deposit has been found below the lignites of Savoy, or that of the Bois de Batie. These lignites, so far as the most recent evidence goes, are on the same horizon as those at Durnthen, about which, as I showed, Heer changed his views. I cannot see, therefore, how in any single instance Mr. Stirrup can sustain his case, and, so far as I know (in the Old World at all events), there is no evidence whatever which is not tainted with doubt and difficulty to support the post-Glacial date of the Mammoth and his companions, while there is overwhelming evidence that their remains occur *under* the so-called Glacial beds.

V.—Note on the Quetta Earthquake of December 20th, 1892.

By Charles Davison, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

On the morning of December 20, 1892, a severe earthquake was felt in the neighbourhood of Quetta in British Balúchistán. Some of the remarkable effects of this shock have already been described in a paper in "Engineering" for May 19, by Mr. R. W. Egerton, the executive engineer in charge of the Shalabagh division of the North-Western Railway. The present note is founded partly on this paper, and partly on further details contained in letters written by Mr. Egerton to his father, Sir. R. E. Egerton, K.C.I.E.[1] and to myself. It will thus be seen that everything that is of value in this paper is due to Mr. Egerton's careful observations; my own part has simply been to edit these notes and to select from them those particulars which appear to me of most interest to geologists.

Fig. 1.



Soon after the close of the last Afghan war a new railway was begun, in order to connect the important positions of Quetta and

[1] My thanks are due to Dr. Lapworth for placing me in communication with Sir Robert Egerton, and to the latter gentleman for the many extracts which he has kindly sent me from his son's letters; also to the publisher of "Engineering" for his courtesy in allowing me to reproduce three of the five illustrations which accompanied Mr. Egerton's paper.

Kandahar with the railway-system of North-western India. Leaving the main line at Sukkur, on the Indus, the new line passes by Jacobabad, Sibi and Quetta; and, about forty or fifty miles beyond the latter place, it cuts through the Khojak Range in a tunnel nearly two-and-a-half miles long, emerging afterwards on the plain of Kandahar. Mr. Egerton's map of the district on either side of the Khojak tunnel is given in Fig. 1. As the country beyond is little frequented by Europeans, the limits of the disturbed area must probably remain unknown, but part or the whole of the epicentrum certainly lies within the district shown in this map.[1]

Mr. Egerton was stationed at Shalabagh, on the east side of the Khojak Range. The shock was felt there at 5.40 a.m. (probably local time), and was strong enough to damage buildings, rendering many of them unsafe, and throwing several down. "In the Khojak tunnel," according to the "Pioneer" newspaper, "the noise was deafening, and workmen engaged on the roofing were thrown from their perches to the ground." After this earthquake slight shocks were frequently felt, sometimes two or three a day during the first month, then almost daily until the end of February, after which the intervals between them became longer, so that during May only about two or three tremors were felt every week. None of these shocks approached the first in severity, though for some time they were strong enough to keep the engineers in continual fear for the safety of the tunnel.

The phenomena of chief interest occurred in the epicentral tract which lies immediately on the west side of the Khojak Range. Between Sanzal and Chaman stations, and about $2\frac{1}{2}$ miles north of the former, both lines of metals, together with the sleepers, were twisted into a loop, as if they had been pieces of string (Figs. 2 and 3). Fig. 3 is copied from a photograph taken by Mr. L. Gordon, the traffic superintendent of the district. Both lines were contorted in the same manner, but the up-line was removed for repairs before the photograph could be taken.

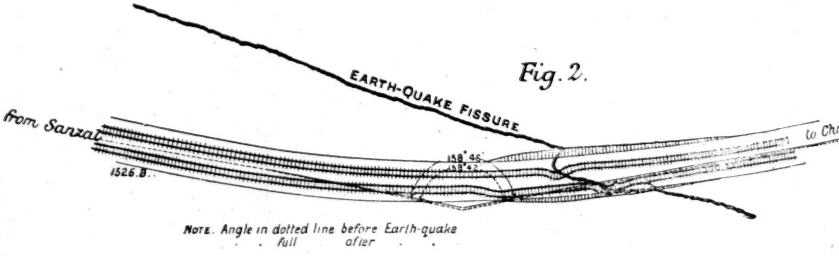
The bending and crumpling of railway-lines is not an uncommon result of severe earthquakes. During the Charleston earthquake of August 31, 1886, the lines were in places bent or displaced for about twelve miles on either side of the epicentrum. In the region of maximum disturbance, the flexures were frequent and sometimes resembled those shown in Fig. 3. Here, the buckling always took place against some rigid obstacle, usually a long rigid trestle, and was accompanied by a corresponding extension of the line in the neighbourhood, by the opening of the joints and shearing of the fish-plate bolts.[2]

In the present case, however, all the neighbouring fish-joints were jammed up tight; and, when Mr. Egerton removed the crumpled lines, it was found that the new lines had to be cut 2 feet 3 inches

[1] Few atlases contain maps of the whole district. A rough sketch-map is given in Chambers's Encyclopædia, vol i., article on "Afghanistan."

[2] Captain C. E. Dutton, The Charleston Earthquake of August 31, 1886; United States Geol. Survey, Ninth Ann. Rep., pp. 283–295.

Fig. 2.



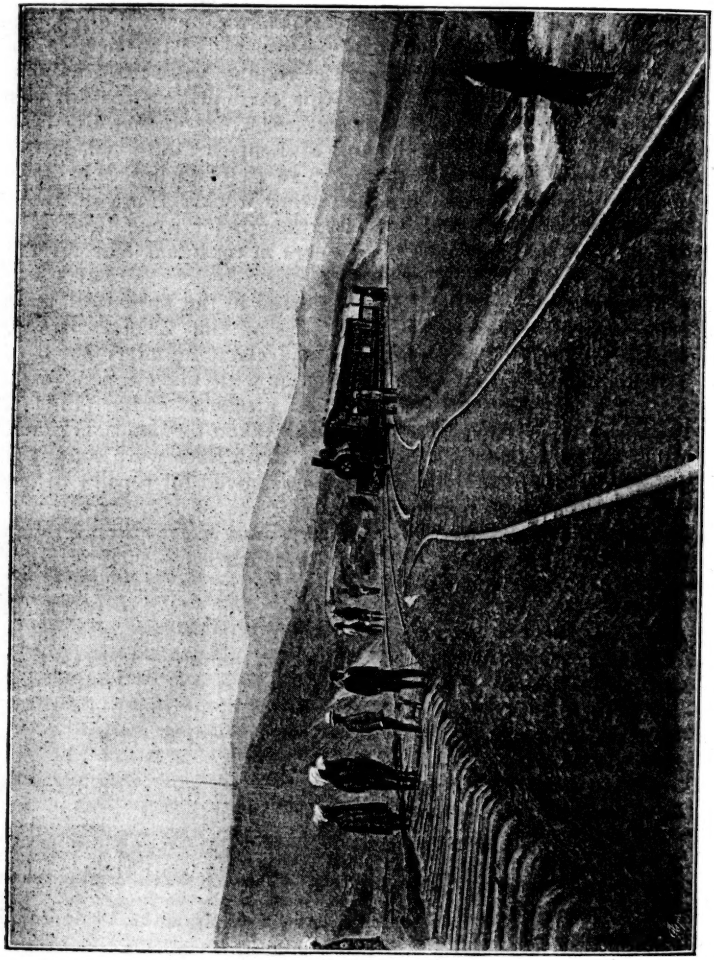


Fig. 3.—Reproduction of Photograph by Mr. L. Gordon, showing distortion of down-line of Rails by Earthquake, between Sanzal and Chaman. (See Mr. A. B. W.'s letter, p. 380.)

shorter than the old ones. There must, therefore, have been an actual and permanent displacement of the earth's crust in this district, not less, and possibly more, than the above amount. It need hardly be said that this is a most unusual occurrence, and one of which every additional illustration and proof is of the greatest value to geologists.

When the earthquake was over, a fresh crack was observed in the ground, crossing the lines at an acute angle exactly at the spot where the crumpling took place. The fissure runs nearly in a straight line, parallel to the Khojak Range (*i.e.* about N.NE. and S.SW.) and about three miles to the west of its central line (Figs. 1 and 2). It coincides almost exactly with a line of springs, and was clearly produced by a fresh slip along an old line of fault. Mr. Egerton has traced the fissure for several miles in both directions. "It was quite curious," he says, "to look at it from certain points which commanded a long view. The old fault-line was then so very obvious that I wonder now how it was never recognized as such before; R—— used to think it was an old road, he told me when I showed it to him." The length of the fault is unknown. Towards the north, it runs out of British territory. Towards the south, it passes just to the east of the low hills in the south-west corner of the map, and it is believed to cross the low neck which joins the Khwaja Amran Peak with the Khojak Range.

It is to be regretted that the actual amount and direction of the movement could not be determined, though Mr. Egerton examined the fissure at various points with this object in view. We may form some idea of its nature, however, from the facts which he has observed. A revision of the levels crossing the fissure shows a difference of ·16 of a foot, or nearly two inches, but it is not stated which side is now relatively the higher. From the crumpling of the lines and closing up of the fish-joints, it is clear that there was a horizontal movement parallel to the fissure; either the west side moved southwards or the east side northwards. Also, it will be seen from Fig. 2 that the curvature of the line near the fissure was slightly less after than before the earthquake. If the movement had been entirely parallel to the fault, the curvature would have been unaltered, or, if anything, slightly increased. There must, therefore, have been motion in a line at right angles to the fault, so that the rock-masses approached one another, implying that the fault is a reversed one. From Fig. 2, again, it would seem that the direction of the railway-line has been changed on the east or Sanzal side of the fissure, and not on the west or Chaman side; showing probably that the eastern rock-mass was moved against the western, as if the Khojak Range were being thrust bodily towards the plain of Kandahar.[1]

FIG. 3.—Reproduction of Photograph by Mr. L. Gordon, showing distortion of down-line of Rails by Earthquake, between Sanzal and Chaman. (See Mr. A. B. W.'s letter, p. 380.)

[1] It may be interesting to compare with this Prof. Milne's account of the changes wrought by the great Japanese earthquake of 1891. "The immediate cause of this great disturbance," he says, "was apparently the formation of a fault which, according to Dr. B. Koto, can be traced on the surface of the earth for a distance of between forty or fifty miles. In the Neo Valley, where it runs nearly N. and S., it

The evidence in favour of this latter point is of course not decisive. But as the natives declare that the ground always cracks along the old fault-line whenever there is a severe earthquake, it is probable that before long Mr. Egerton and his colleagues may be in a position to renew their very interesting observations, and thereby to extend our knowledge of the crust-movements that are now taking place.

NOTICES OF MEMOIRS.

RESEARCHES ON THE STRUCTURE, ORGANIZATION, AND CLASSIFICATION OF THE FOSSIL REPTILIA. Part VIII. On Further Evidences of *Deuterosaurus* and *Rhopalodon* from the Permian Rocks of Russia. By Prof. H. G. SEELEY, F.R.S. Royal Society, June 8, 1893.

THE author endeavours to separate the Labyrinthodont remains, distinguished by having teeth anchylosed to the jaw, from such as belong to animals having a Theriodont type of dentition. The genera founded upon cranial fragments which show the Theriodont type are *Deuterosaurus*, *Rhopalodon*, and *Dinosaurus*. The skull in *Deuterosaurus* is described from new materials, which make known the structure of the palate and other cranial structures. The palate is of Plesiosaurian type. The back of the skull is a vertical plate, and the brain cavity rises in a long vertical tubular mass to the parietal foramen. The quadrate bones descend below the foramen magnum in a way that is best compared with Plesiosaurs.

The articular end of the lower jaw is identified among bones figured by von Meyer.

The skull of *Rhopalodon* is nearly complete, and has a general resemblance to the skull of the South African Dicynodont *Ptychognathus*. The orbit is defended with a sclerotic circle of bones. Whereas in *Deuterosaurus* there is only one molar tooth, in *Rhopalodon* there are apparently eight molar teeth, which have the posterior edge finely serrated.

The vertebræ are known from isolated and connected specimens which indicate a larger number than usual of rib-bearing presacral vertebræ, which appear to be not fewer than nineteen, and may have numbered twenty-six. The sacral vertebræ are deeply cupped, and the sacral ribs are developed as in *Nothosaurus* and *Pareiasaurus*. The sacral ribs form part of the articular face of the first sacral vertebra. The pelvis is imperfectly known; the ilium is not so

looks like one side of a railway embankment about 20 or 30 feet in height. . . . . Not only is there evidence of subsidence along this line, but there are many evidences of horizontal displacement. Lines of roads have been broken, and one part of them thrown to the right or left of their original direction; whilst fields which were rectangular have been cut in two, and one-half relative to the other half been shifted as much as 18 feet up or down the valley. One result of this is that landowners find there has been a partial alteration in the position of their neighbours. A more serious change has been the permanent compression of ground, plots which were 48 feet in length now measuring only 30 feet in length. It appears as if the whole Neo Valley had become narrower. A similar effect is noticeable in the river-beds, where the piers of bridges are left closer together than they were at the time of their construction."—Brit. Asso. Rep. 1892, pp. 116, 117.

extended as in Dicynodonts, and conforms to the type of *Phocosaurus*, which is regarded as Theriodont. The pubis and ischium are united together on the Dicynodont plan, but are only moderately developed.

The scapular arch is completely known, and is formed of scapula, coracoid, and pre-coracoid, as in *Dicynodon* and *Pareiasaurus*. The humerus and bones of the fore limb were relatively short, and only fragments have been preserved which appear to be referable to ulna and radius.

The hind limb is known from several examples of the femur, which resembles that of *Pareiasaurus* in the proximal end, but at the distal end is more like the type described as *Saurodesmus*.

The tibia is known from its proximal and distal ends; it has a general resemblance to that of *Pareiasaurus*, but is more slender. These types are regarded as constituting a distinct group, named Deuterosauria, which is in many respects intermediate between the Placodontia and Theriodontia, but in skull structure appears also to approach Nothosaurs and Plesiosaurs.

REVIEWS.

I.—Text-Book of Comparative Geology. By E. Kayser, Ph.D. Professor of Geology in the University of Marburg. Translated and Edited by Philip Lake, M.A., F.G.S., late Harkness Scholar in the University of Cambridge. 8vo. pp. 426, with 596 Illustrations, 73 Plates and 70 Figures in the Text. (London: Swan, Sonnenschein & Co., 1893.)

In undertaking the translation of Dr. Kayser's "Lehrbuch der geologischen Formationskunde" Mr. Philip Lake has done more than preparing a mere translation. Dr. Kayser's work was intended primarily for use in Germany, it has therefore been found desirable, in the present edition, to very considerably enlarge those portions of the work which deal with descriptions of extra-German countries. Mr. Lake has taken the advice of several of his geological colleagues, whose assistance he duly acknowledges, and amongst other modifications he has introduced the divisions Cambrian, Ordovician, and Silurian, instead of the older subdivisions into Cambrian and Silurian only.

In the introduction the author gives a history of the names which have been adopted in this country and in Germany for the great series of stratified deposits, and the various subdivisions now generally recognised by geologists both at home and abroad.

Division I treats of the general characters and composition of the Archæan rocks, illustrated by ten sections. The total thickness of the Archæan in North America has been estimated at 50,000 feet, and in Bohemia at 100,000.

In II the Palæozoic or primary group is considered, comprising the Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian, the six systems forming together a succession of beds fully 100,000 feet thick.

Under "Cambro-Silurian Rocks" the author gives an epitome of what has taken place with regard to the subdivisions adopted by Sedgwick, Murchison, the Geological Survey, Lyell and finally Lapworth. The general consensus of opinion seems now to be in favor of the acceptance of Professor Lapworth's tripartite division:

Silurian	Downtonian Salopian Valentian	
Ordovician	Bala Series Llandeilo Arenig and Llanvirn Tremadoc Slates	
Cambrian	Lingula Flags:	*Olenus* Beds
	Menevian Harlech, &c.	*Paradoxides* Beds
	Comley Sandstone:	*Olenellus* Beds
	Caerfai group	

Under each subdivision the English and Foreign equivalents will be found together, with upwards of a hundred figures of the characteristic fossils that mark the several stages.

Thirty-six pages are devoted to the Devonian System, principally based on foreign localities; but a summary is given of (1) the succession of beds in North and South Devon, consisting of a series of slaty, sandy, and calcareous beds, which in all points resemble that of the continent, and (2) a thick red sandstone series, distinguished by a rich and peculiar fish fauna, the Old Red Sandstone.

The author gives tables of the Devonian rocks as shown in the Rhine area; the Ardennes; in Thuringia and in the Alps; in France; Spain and Portugal; in Bohemia; the Urals in Russia; and in North America. The Palæontology is carefully dealt with and illustrated by upwards of seventy wood-cut figures of fossils.

Thirty-eight pages are devoted to the Carboniferous System and its palæontology, with sixty illustrations besides sections of strata.

The Permian is next described, special attention being given to its European development, it having been known longest in Central Germany, especially about Mansfeld, where, for centuries, important mines have been worked in the Permian Kupferschiefer, and where the old names, Rothliegende and Zechstein, had their origin.

Its distribution in Germany, France, Britain, Russia, the Alps, Sicily, Asia, America is given; it is also recorded from Spitzbergen and New Scotland, Australia, India, and Africa. Upwards of thirty figures of Permian fossils are introduced.

III. The Mesozoic or Secondary group commences with the Trias, to which forty-one pages are devoted. Stress is laid on the great difference between the "German" and "Alpine" facies of the Trias; in the former, with the exception of the calcareous Muschelkalk, the beds are mainly sandy or argillaceous rocks,—in England indeed these form almost the whole series. In the Alps, on the other hand, the sandy rocks are very much reduced in comparison with the massive pure limestones, dolomites, and marls.

In Germany only the Muschelkalk contains a fauna of any abund-

ance, the Keuper and Bunter being very unfossiliferous. But the Muschelkalk even is poor when compared with deposits of the same age in the Alps. This is especially true of the deep-sea Cephalopoda, which in the German Trias are known by a few small species, but in the Alpine Trias by a whole series of rich faunas. The wide-spread Alpine Trias is the pelagic facies of the formation; the more restricted German Trias, on the other hand, is a shallow shore, bay, or inland sea formation. The fossils of this division are illustrated by about seventy woodcuts, and comparative tables of the German and Alpine Trias in various areas are given.

Forty-four pages are devoted to the Jurassic System and seventy figures to the illustration of its fossils.

Tables are also furnished of the Liassic and Oolite strata and their equivalents abroad.

Forty-six pages contain the Cretaceous system, illustrated by ninety figures, whilst seventy-three pages, and one hundred and twenty figures are devoted to the Tertiary Age.

Making due allowance for the difficulties of bringing out such a work, the author and translator may both be congratulated on the satisfactory appearance of the English Edition.

The figures are mostly needlessly large, which is a misfortune, causing them to take up too much space; the Mammoth and Irish Deer should be condemned as bad, and we should like to see more regard paid to the *relative proportions* of the figures of natural objects used in such works as the present.

Prof. Prestwich, in his admirable Manual of Geology (1888), has set an example in the matter of illustrations which other writers on palæontology might do well to follow.

For a small handy volume, we must commend Mr. Lake's translation of Dr. Kayser's Geology as worthy of a place in any library, forming a useful and trustworthy guide-book to the student. The facts are clearly and carefully given, there is a good index, and the price of the volume is conveniently small.

II.—The Glacial Nightmare and the Flood, a Second Appeal to Common-Sense from the Extravagance of some Recent Geology. By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S. Two vols. 8vo. pp. xxviii., xii., and 920. (London: Sampson Low, Marston, & Company, 1893.)

THE name of Howorth has long been familiar to the readers of the Geological Magazine, as a constant contributor since 1880, on "The Mammoth in Siberia," "The Mammoth in Europe," "On the Loess," "Traces of a great Post-Glacial Flood," "The Mammoth and the Glacial Drift," etc. Many of the chapters of his first great book, "The Mammoth and the Flood," which some of his friends playfully called a "Monster Book," appeared in the monthly numbers of this Magazine, as have also portions of this his newest publication.

"One of the chief objects," says Sir Henry Howorth, "of this book, is to show that the Glacial theory, as usually taught, is not sound; but that it ignores, and is at issue with, the laws which

govern the movements of ice, while the geological phenomena to be explained refuse to be equated with it. This is partially acknowledged by the principal apostles of the ice-theory. They admit that ice as we know it in the laboratory, or ice as we know it in glaciers, acts quite differently to the ice they postulate, and produces different effects; but we are bidden to put aside our puny experiments which can be tested, and turn from the glaciers which can be explored and examined, to the vast potentiality of ice in shape of portentous ice-sheets beyond the reach of empirical tests, and which we are told acted quite differently to ordinary ice. That is to say, they appeal from sublunary experiments to *à priori* arguments drawn from a transcendental world. Assuredly this is a curious position for the champions of uniformity to occupy. In regard to it I will quote a fable already utilized by Hugh Miller. A wolf, says Plutarch, peeping into a hut where a company of shepherds were assembled, saw them regaling themselves with a joint of mutton. 'Ye gods!' he exclaimed, 'what a clamour they would have raised if they had caught *me* at such a banquet.'

"I hold that the Glacial Theory, as ordinarily taught, is based, not upon induction, but upon hypotheses, some of which are incapable of verification, while others can be shown to be false, and it has all the infirmity of the science of the Middle Ages. This is why I have called it a Glacial Nightmare. Holding it to be false, I hold further that no theory of modern times has had a more disastrously mischievous effect upon the progress of Natural Science. It is not merely in the domain of geology that its baneful influence will be felt. We cannot take up a text-book in which the profounder problems of biology are treated, problems like the distribution of animals and plants, the pedigree of life, the origin and beginnings of the human race, without being impressed with its influence as a factor." . . . . . .

"What then is shortly the burden of the following argument? I admit completely, that the position maintained by Charpentier in his work on Glaciers is unassailable, first, because it makes no appeal to any occult and hidden forces underlying the movements of ice, but proves the existence of greater glaciers formerly by comparing and equating the ruins they have left with the ruins made by existing glaciers. Secondly, because it is consistent with all the geological facts that we can summon to test it by. On the other hand, I not only disbelieve in, but I utterly deny, the possibility of ice having moved over hundreds of miles of level country, such as we see in Poland and Russia, and the prairies of North America, and distributed the drift as we find it there. I further deny its capacity to mount long slopes, or to traverse uneven ground except when under the impulse of gravity. I similarly deny to it the excavating and denuding power which has been attributed to it by those who claim it as the excavator of lakes and valleys, and I altogether question the legitimacy of arguments based upon a supposed physical capacity which cannot be tested by experiment, and which is entirely based upon hypothesis. This means that I utterly question the prime postulate of the glacial theory itself."

What then is the alternative which Sir Henry Howorth offers for our acceptance in lieu of the glacial theory which he contemns? "It is a widespread flood, which seems to be a necessary postulate, if we are to adequately grapple with the extinction of the Pleistocene fauna, and an equally necessary postulate if the geological facts are to be duly explained." . . . . . .

"The Pleistocene Flood, though far from being universal, was certainly one of the most widespread catastrophes which the world has seen. It forms a great dividing-line in the superficial deposits as was maintained long ago, and as such it is a very useful landmark which ought to appear in our nomenclature, and I do not know of any better terms than ante-diluvian and post-diluvian to mark the two great divisions of the post-Pliocene-beds.

"Ante-diluvian times, so far as we can see, were marked in the temperate latitudes of both hemispheres by accumulations of ice in the shape of large glaciers on the high lands (then probably much higher) of Western Europe, of North America, of Australia, New Zealand, and perhaps South Africa. Alongside of these glaciers, and in contact with them in all these latitudes, were wide champaign and wooded districts in which the Mammoth and the Woolly Rhinoceros were the most prominent animals in North Asia and Europe, the Mammoth and the Mastodon in North America, the Mastodon and the great Sloths in South America, the various species of gigantic Kangaroos and Wombats in Australia, the great wingless birds in New Zealand. They lived and thrived in the near neighbourhood of the ante-diluvian glaciers, just as the Apteryx now thrives in the luxuriant forests near the great glaciers in New Zealand, and just as the Tiger and the Rhododendron thrive close to the Himalayan glaciers.

"Meanwhile, in Northern Asia and Western Europe and in North and South America certainly, and probably also in Australia, ante-diluvial man lived alongside of and hunted the ante-diluvian animals, and if we are to clear up his pedigree we must find the true interpretation of these ante-diluvian beds.

"Presently came a tremendous catastrophe, the cause of which, as I have tried to show in the GEOLOGICAL MAGAZINE, was the rapid and perhaps sudden upheaval of some of the largest mountain-chains in the world, accompanied probably by great subsidences of land elsewhere. The breaking up of the earth's crust at this time, of which the evidence seems to be overwhelming, necessarily caused great waves of translation to traverse wide continental areas, as Scott Russell, Hopkins, Whewell, and Murchison argued they would, and these waves of translation as necessarily drowned the great beasts and their companions, including palæolithic man, and covered them with continuous mantles of loam, clay, gravel, and sand, as we find them drowned and covered. They also necessarily took up the great blocks which the glaciers had fashioned, and transported them to a certain distance and distributed them, and the drifts associated with them, as we find them distributed.

"This Induction, whose details are contained in the following

pages, seems to me to be complete, not only because it adequately explains the facts, but because it is the only theory that does so, and I know nothing against it, but the almost pathetic devotion of a large school of thinkers to the Religion founded by Hutton, whose High Priest was Lyell, and which in essence is based on *à priori* arguments like those which dominated mediæval scholasticism and made it so barren."

Truly, time brings its revenges! The school of Cataclysmists and Convulsionists, which, 25 years ago, we believed had entirely died out, has found a most powerful advocate in Sir Henry Howorth. Even the most extreme of glacialists must feel a glow of satisfaction in the thought that their opponent advances cataclysmic views as piping hot as theirs are frigidly cold.

Humboldt's Jorullo, run up in a single night, is as a rushlight to the mighty Himalayas jerked up by Sir Henry Howorth in a week!

Nor can the glacialists pretend to any chance of competition with the author in monster Ice-sheets compared with a Flood so extensive as he presents for our immersion.

Assuming Sir Henry Howorth is right in his theory and all other geologists wrong, how comes it that the pigmy descendants of the giant sloths and the mighty *Glyptodon* should be found occupying the same area in South America as their huge forefathers, and that the extinct *Diprotodon* and *Nototherium* of Australia should be represented by corresponding but lesser living forms of Marsupials in that area to day? May not each and all the changes in the mammalian and avian faunas of the various great regions of the earth have been due to causes which have acted independently in each great area, and which may have been brought about by very distinct and separate agencies? Thus the great Marsupialia of Australia may have owed their extermination to a succession of dry seasons, which, as Sir Richard Owen pointed out, always affect the larger animals first, by producing scarcity of food and water. The great *Dinornithidæ* in New Zealand probably owed their extermination partly to forest-fires, but chiefly to the arrival of the Maoris, who doubtless lived upon them as long as any remained.

The giant Edentata of South America may have gradually succumbed to *local* floods, from which their terrestrial habits and their bulk afforded them no escape, whereas their smaller relatives, perhaps, by greater activity and arboreal habits, may have survived.

The gigantic Irish Deer may well have perished, in its final insular and limited home, from wolves, or wet seasons, which the altered land-conditions, due to the subsidence of the Irish Sea-valley (once dry land), may have brought about.

Be the causes what they may, it appears to us most unphilosophical to attempt to connect the extinction of all these animals, living in such widely-separated countries, with *one* overwhelming *debacle*, and to denounce the followers of uniformitarianism and condemn their tenets as unsound, yet at the same time to offer a universal deluge as the sure, safe and only panacea for all Pleistocene geological difficulties!

So nearly do the author's researches and results approach the subject of what is usually termed the Universal or Mosaic Deluge,

that he is quite right to express his views as to the propriety of leaving the Biblical account alone; he tells us that it is not worth being measured by scientific forms of thought, and quotes Bacon and Sedgwick with appositeness, as to "the impossible task of equating science and faith."

"This vanity merits castigation and reproof the more, as, from the mischievous admixture of divine and human things, there is compounded at once a fantastic philosophy and a heretical religion"[1]

As to the extreme views maintained by some Glacialists we happily have nothing in common, and we gladly leave them to controvert Sir Henry Howorth's objections as best they can. (In matters of *argument* we notice that Sir Henry generally gets the best of his opponents!) Their condition in our opinion is very similar to that of the believers in the permanence of continents and oceanic basins. These are but the *fashions* of geology, "they have their entrances and exits," its *facts* are what we are most careful to gather, let those theorise who will! *Magna est veritas, et prævalebit.*

III.—Beiträge zur Geologie und Palæontologie von Sudamerika. 1. Palæozoische Versteinerungen aus Bolivien von Dr. Arnold Ulrich. Neues Jahrbuch für Mineralogie, etc. Beilageband viii. 1892, pp. 116, pls. i.–v.

Contributions to the Geology and Palæontology of South America. 1. Palæozoic Fossils from Bolivia. By Dr. A. Ulrich.

THIS memoir is intended as the first of a series of sketches on the geology and palæontology of South America, based on the observations and collections made by Prof. G. Steinmann, who in a brief introduction gives an outline of the route followed during his late expedition to that Continent. With the exception of a few poorly-preserved Silurian fossils, Dr. Ulrich's memoir consists of a description of a comparatively rich and well-marked fauna of Devonian age, mainly obtained from the highlands of Eastern Bolivia—some of the rocks are now at an elevation of 4,500 mètres above the sea. The greater portion of this elevated country is built up of Devonian strata, which show two distinct series, of which the lower or Icla series principally consists of shaly beds reaching a thickness of 300 to 400 mètres; the higher portion of these, known as the '*Conularia*' beds, is by far the most fossiliferous. The higher series, the thickness of which is not given, is mainly of sandstone and is known as the Huamampampa sandstone. Fossils have been found only in the lower beds of this series, and there is not a single species in common with the underlying Icla series.

The fauna in these beds includes various species of Trilobites, *Conularia*, *Hyolithus*, Gasteropoda, Lamellibranchiata, and numerous Brachiopods; in all, between 60 and 70 species, which have been carefully worked out and figured by Dr. Ulrich.

This fauna is purely Devonian in character, and it is chiefly remarkable for a strong resemblance to the Devonian fauna of the

[1] Sedgwick's paraphrase of Bacon, Ann. Address, Q.J.G.S., vol. xxii.

Eastern portion of the United States and Canada, and, what is still more strange, to that of the Cape region of South Africa, judging from the fossils collected by Bain and worked out by Salter and Sharpe; and also to the Devonian Fauna of the Falkland Islands discovered by Darwin and described by Morris and Sharpe. The author gives lists of the Bolivian species and of the corresponding species in the countries just mentioned, which show very distinctly the striking relationship of many of the fossils in these widely separated areas.

To give one or two examples from the brachiopoda: *Leptocœlia flabellites*, Conrad, sp., is a well known form in the Oriskany sandstone and Upper Helderberg of North America; it is very abundant in Bolivia, and the same species or a closely allied variety has been described from the Falkland Islands and from South Africa under the name of *Orthis palmata*, Morr. and Sharpe, whilst curiously enough, it is not recorded from Devonian rocks in other areas, and it is unknown even in the Devonian rocks of Brazil. *Tropidoleptus carinatus*, Conrad, sp. and *Vitulina pustulosa*, Hall, again, are two very distinctive species of local occurrence in the North American Devonian; they have a nearly similar distribution as *L. flabellites*, but the former occurs as well in Brazil, and is considered by the author to be the same as *Strophomena laticosta*, which is found in the Devonian of this country and other parts of Europe; whilst the latter species is restricted to N. and S. America and S. Africa, and is not found in any other region.

From a review of the whole of the fauna, Dr. Ulrich considers that the Icla shales correspond to the horizon of the Corniferous Group, and the Huamampampa sandstone to that of the Hamilton Group in the Devonian series of N. America. The Devonian beds both in S. America and in S. Africa appear to be shallow water deposits, and they resemble each other in the comparative rarity of Cephalopods and corals. The very striking facts relating to the distribution of these Devonian fossils which the author has brought to light in the present memoir, deserve the careful consideration of all interested in palæontology.

IV.—Sveriges Kambrisk-Siluriska Hyolithidæ och Conulariidæ. Af Gerhard Holm. With an English Summary. Sveriges Geologiska Undersökning. Ser. C. No. 112. Stockholm, 1893. On the Hyolithidæ and Conulariidæ in the Cambrian and Silurian Strata of Sweden. By Gerhard Holm. 4to. pp. ix. and 173, pls. i.–vi.

THE shells included in these two families have been generally ranked with the Molluscan order Pteropoda; but considerable doubt of their right to this position has been expressed by Pelseneer, one of the best authorities on recent Pteropods, who is unable to find any resemblance on which relationship could be based between the fossil forms and the existing members of this division. The author agrees with this view and apparently considers both these families as extinct and their systematic position uncertain, and he further

points out that they are not in any way related to each other, so far as can be judged by the character of the shell; for whilst in the Hyolithidæ this is tolerably thick, not flexible, of at least three distinct layers, and mainly of carbonate of lime; in the Conulariidæ it is thin, apparently flexible, and mainly composed of phosphate of lime and chitinous material. Whilst in *Hyolithus* the shell is bilaterally symmetrical with a differentiated dorsal and ventral surface, in *Conularia* the shell is pyramidal, with a square or rhombic section, and with each side marked by a longitudinal median line known as the segmental line. A further difference is shown in the fact that *Hyolithus* is provided with an operculum and the aperture is not contracted, whilst in *Conularia* there is no operculum, and the upper portion or mouth of the shell seems to have been furnished with inwardly bending flanges.

Besides these two well-marked families, Dr. Holm proposes another—Torellidæ, based on *Hyolithus lævigatus*, Linnars., the shell of which is of phosphate of lime and thus resembles *Conularia*; but unlike this genus, it is elliptical in section, both sides of the shell are alike, and it is without other ornament than lines of growth. This form probably belongs to the Annelida, and the author also places in the same group the genera *Tentaculites* and *Salterella*.

In the family Hyolithidæ, the author only recognizes the single genus *Hyolithus*, Eichwald; but this may be divided into *Hyolithus*, sens. str. and *Orthotheca*, Novak. This latter sub-genus includes the simpler original forms of conical shells with no other markings but lines of growth, in which the aperture is in a single plane and the operculum is a plane, or gently conical and without a semi-conical dorsal portion. In the higher developed *Hyolithus*, sens. str., the dorsal margin of the aperture has a semicircular extension, so that the aperture is formed by two planes meeting at an obtuse angle, and the operculum to fit this aperture, consists of a small lunate ventral portion and a larger semi-conical dorsal portion.

Of the other genera hitherto included in this family, *Camerotheca*, Matthew, *Diplotheca*, Matt. and *Pharetrella*, Hall, are brought within the type genus, whilst others, as *Coleoprion*, Sandb., *Coleolus*, Hall, *Clathrocælia*, Hall, *Hemiceras*, Eichw. and *Hyolithellus*, Bill., are rejected as having no relationship with it; this latter genus is stated to be based on the brachiopod shell, *Discinella*. *Cleidotheca*, Salt., is founded on the assumption that some of the forms were destitute of an operculum, and *Centrotheca*, Salt., on a probable misinterpretation of the characters of the type form, *C. cuspidata*, Salt.

Through Dr. Holm's investigations the number of species of *Hyolithus* from the Swedish Cambrian, Ordovician (or Lower Silurian), and Silurian strata has been increased from 6 to 44; the greater portion of these are from Öland. From the Lower Cambrian or *Olenellus* region 7 species are recognized; from the Middle Cambrian or *Paradoxides* beds, 15 species; whilst they are scarcely at all present in the *Olenus* division. In the Ordovician or Lower Silurian, the *Endoceras vaginatum* region proved the richest, yielding 11 species all limited to it, whilst there are several related species in

the higher *Lituites* region. In the *Chasmops* beds only a single species is definitely known, whilst the three species met with in the *Trinucleus* division belong to the sub-genus *Orthotheca*. From the Upper Silurian only three species were discovered by Lindström in the Isle of Gotland.

As regards the relationship of the Swedish forms of *Hyolithus* to those occurring in other countries, there is a considerable resemblance to those from North America, and the Lower Cambrian forms from that country described by Walcott correspond with those from the Middle Cambrian of Sweden. Owing to the imperfect preservation of the British species no comparison is practicable. There does not appear to be a single species in common with those from the Bohemian basin, though these latter are numerous and fairly well-preserved, and thus this group tends to confirm the evidence from the Trilobites, Gasteropods and Cephalopods that there was no direct connection between these areas at the period.

From a table giving in detail the references to the names, authors, and the distribution of the known species in the Cambrian-Silurian rocks, it appears that 55 species occur in the Cambrian, 68 in the Ordovician, and 22 in the Silurian series; and if to these are added 34 species from the Devonian, Carboniferous, and Permian rocks, the total number of species of this group reaches 178.

In the family Conulariidæ only the single genus *Conularia*, Miller, is recognised. The earliest known species is from the summit of the Cambrian in North America. The genus reaches its culmination in the Ordovician and continues apparently as far as the Lias. In Sweden there are 12 species from the Ordovician, 5 from the Silurian, and one common to both. Only one of these, *C. cancellata*, is common to the Bohemian basin and this species is widely distributed over the Continent of Europe, and probably is identical with *C. niagarensis*, Hall, from the Silurian of N. America.

As a rule the shell in these fossils is well-preserved, with the finest details of ornamentation, and the author has attempted a division of the genus into four groups, based on the surface sculpturing and the character of the segmental lines. In the first group, *Læves*, the shell exhibits only transverse wrinkles formed by the lines of growth, and the segmental line is depressed. In the second, *Longitudinales*, there are raised longitudinal ribs and the segmental line is elevated; in the third, or *Moniliferæ*, there are transverse ridges or rows of tubercles; whilst in the fourth, or *Cancellatæ*, the transverse main ridges are interrupted, and finer longitudinal ridges are likewise present.

The specific descriptions are accompanied by carefully drawn figures, showing the fossils and their surface characters enlarged, which thus greatly facilitate comparison with other forms. For the convenience of those to whom Swedish is unknown, the author has appended a short summary in English, giving a synopsis of the different species. G. J. H.

V.—Description de la Faune Jurassique du Portugal. Mollusques Lamellibranches. Par Paul Choffat, Premier Ordre Siphonida Première Livraison. Pages 1 à 39 et Planches I. à IX. Lisbonne, 1893.

WE do not appear to get much in the way of geology from Portugal, but what we do get is good. Here is another instalment of the description of the Jurassic Fauna by one whose previous contributions in the same direction have given us every confidence in their value. This particular section plunges at once *in medias res* and gives us a Monograph of the Jurassic *Pholadomyæ* of Portugal. The difficulties under which work is done in that country is curiously revealed by the few words of Preface, from which we learn that the text and plates were all ready in 1883, except plate i., which was intended to illustrate family matters, *i.e.* the families of *Pholadidæ*, *Myidæ*, and *Anatinidæ*; but the author had no artist at his disposition! Even now the plate is used, not as intended, but for new species of genera allied to *Pholadomya*. It is certainly a question whether this curious lack of artists is not a blessing in disguise, for the result is that the nine beautiful plates are all photographic representations, in permanent phototype print, of the actual specimens; nothing whatever in them is liable to the personal equation. This is, perhaps, specially advantageous in the case of such rough things as *Pholadomyæ*, where so much depends upon the shape, the strength, or otherwise, of the ridges, on the cardinal area and the character of the radiating ribs. And for another reason, as will be seen presently, it is a good thing to have as many figures as the author will give us of the Portuguese forms.

It appears that the Lias, at least, presents two distinct facies—one in which the succession can be fairly compared with that in Central Europe, and the other peculiar to the Iberian Peninsula. As several species of the *Pholadomyæ* occur in both, this should be an aid in correlation.

When, however, we come to examine this work in detail we get into a little difficulty. There always have been two types of Palæontologists: the one type divides and subdivides till almost every specimen is a species, and if there is any character common to them all, other than the one on which he has set his affections as the discriminator, they are said to show a remarkable "convergence," they are "homoplastic," "morphological equivalents," and all the rest of it. The other type seizes, perhaps, this very one of all the characters, as the bond of union into a "good species" of forms of which it may at least be said that if one gave birth immediately to the other the offspring would be considered a monstrosity. The one type also so subdivides the strata in which these fossils lie that the successive species must be as crowded in their "beds" as a family in a London slum; while the other gives his species so great an immortality that it crops up in formation after formation. Which of these two types will gain the ultimate victory, or whether both will be united or swept away by something more comprehensive, it is hard at present to say.

Meanwhile our author belongs to the second type. He describes all the previously known species of *Pholadomya*, ranging from the Lower Lias to the Kimmeridge, under 19 names, which include no less than 60 of those recognized by his predecessors, and of these *P. decorata* runs from the Lower Lias to the Inferior Oolite, *P. Murchisoni* from the Bajocian to the Callovian, and several others have nearly as wide a range; even these are said to show passages into each other, and the last named is said to be certainly the origin of *P. exaltata*. It is very probable that these two types of palæontologists represent two phases in the evolution of the geological knowledge of a country. In the earlier stages, when only an outline of the geology is known and the workers are few, it may be necessary to take a more general view; but as the details of the stratigraphy become familiar it is possible to come to closer quarters with the question of the succession of forms, and it is certain that the solution of this question can never be obtained without the most minute discrimination of varieties, while a correct one is impossible if in the midst of these details we lose sight of the wider laws.

As a sort of appendix we have descriptions of *Arcomya* and *Goniomeris*, a new genus, and it is a curious thing that all the species in these two genera are described as new. This part was written later. If species are taken in as wide a sense here, as the author does in the genus *Pholadomya*, one fancies one could match some of these amongst old Corallian friends. Has the author's idea of species become more limited in the interval? J. F. B.

VI.—The Iron-ores of Great Britain and Ireland, their Mode of Occurrence, Age, and Origin, and the Methods of Searching for and Working them (with a notice of some of the Iron-ores of Spain). By J. D. Kendall, F.G.S. 8vo. pp. xvi. and 430, with Illustrations. (London: Crosby, Lockwood & Son, 1893.)

IRON may justly claim to be one of the most important of all the elementary substances, not only by reason of its vast economic value to mankind, but also from its distribution in rocks of all ages which build up the framework of our globe and it is probably equally widely distributed throughout the universe.

Its presence in the stratified deposits is indicated by their colouring, which is no doubt largely owing to this metal. Rusty-brown tints are due to hydrated peroxide of iron; brighter red tints, and sometimes darker stains, are due to anhydrous peroxide of iron; greenish colours are produced by the protosilicate, and bluish tints are imparted by bi-sulphide of iron.

Notwithstanding the immense abundance of iron in the earth's crust, *metallic iron*, in a more or less pure condition, is but rarely met with. Indeed, until of late years, it was believed that all, or nearly all, such metallic iron was of extra-telluric, or meteoric origin, with the exception of ferruginous metallic platinum. True meteoric iron usually, if not invariably, contains nickel, to the extent of 1 or 2 parts per 100 of iron, up to considerably larger amounts; the Pallas Meteorite, Siberia, containing nearly 11 per

cent., and the Cape of Good Hope meteorite 15 per cent. of nickel. Although the Ovifak, Greenland, irons were at first considered to be true meteorites, subsequent investigations led to the detection of spangles and grains and lumps of iron inclosed in the eruptive rock itself, adjacent to the larger loose blocks of iron; so that it is possible that these masses of iron may have welled up with the igneous rock from some very deep-seated source of telluric energy, and that our own earth may, in its interior, possess a large supply of metallic iron in addition to the vast stores of oxides and sulphides distributed through its sedimentary crust.

The compounds of iron, with various other substances which constitute the ores of iron, are very numerous.

Of these, "hæmatite," the anhydrous peroxide, known as *red* hæmatite, is that most commonly used for metallurgical purposes. Its composition is iron 70, oxygen 30=100.

Hæmatite occurs in the Coniston Limestone (Ordovician) of Millom; and in West Cumberland and Furness in the Carboniferous series. "Limonite" (hydrous peroxide or brown oxide), Magnetite (peroxide and protoxide of iron) and "Siderite" (or "chalybite," carbonate of protoxide of iron) in the Devonian rocks of Cornwall, Devon and Somerset.

As one would naturally expect, with the development of our Coal-fields, the interstratified seams of clay ironstone of Coal-measure age were for a very long time, extensively worked in the South Wales Coal-field; in Shropshire and North Staffordshire, in Northumberland and Durham, and in the Glasgow Coal area, and elsewhere.

"Thirty-six years ago these rocks yielded four-fifths of the ore raised in Great Britain; but since the introduction of the more cheaply worked ores of the Secondary rocks, this proportion has been gradually reduced, until now these measures do not produce more than one-sixth of the total raised. Not only has there been this great relative fall, but there has been an absolute diminution in the production of clay-ironstone to the extent of about 5,000,000 tons per annum. Every year this source of supply becomes less important; the only districts at present raising any considerable quantity being North Staffordshire and Scotland" (p. 145). The following table gives the

Comparative amount of Ore Raised and Consumed in the United Kingdom.

	Tons in 1855.		Tons in 1890.
From the Secondary Rocks...	1,044,384	.....	9,060,169
,, Carboniferous Rocks	8,478,860	.....	4,838,977
,, Other Rocks	30,497	.....	54,792
Total...	9,553,741	.....	13,953,938

"It is thus seen that the output from the Coal-measures has, during the time embraced in these tables, fallen about 46 per cent., whilst that from the Secondary rocks has increased nearly 900 per cent. (p. 201)."

"*Deposits in the Lower Lias.*—The only deposit of iron-ore in these rocks that have been worked up to the present time occurs at Frodingham, in North Lincolnshire. For a long time it was con-

sidered, and perhaps by some is still thought, to be the equivalent of the Cleveland main bed; but there is now not any doubt whatever that it is in a much lower geological horizon. It occurs in the zone of *Ammonites semicostatus*, which in Cleveland is about 480 feet below the main seam of ore, although at Frodingham it is only about 161 feet below the equivalent of the latter bed, owing to the south-easterly attenuation of the rocks as previously mentioned. The ore occurs in the form of a bed, with a gentle inclination towards the east. Its maximum thickness is only about 25 feet; but owing to its slight dip, combined with the level nature of the ground, its outcrop occupies a wide stretch of country."

The following section was obtained in sinking a shaft to the ore between Appleby village and the railway station:—

		ft.	in.	Zone of
	Limestone (Lincolnshire)	36	8	
Upper Lias	Blue Shale	34	4	
	Sandstone	1	11	[*nis.*
	Grey Shale	25	10	*Ammonites commu-*
Middle Lias	Ironstone (Cleveland Main Seam)	7	10	*A. spinatus.*
Lower Lias (upper part only).	Shale with cement stone nodules ...	67	6	*A. capricornus.*
	Ironstone (Pecten bed)	4	6	*A. armatus.*
	Blue Shale	89	9	*A. raricostatus.*
	Ironstone (Frodingham main bed)	22	6	*A. semicostatus.*

This is followed by a careful and elaborate description of the "Cleveland Ironstone" from which more ore is raised in England than from any other formation.

The main seam of Ironstone is the only one that has been wrought extensively, though a lower seam has been worked in one part of the district.

The main seam has been proved to extend over a very large area, probably exceeding 350 square miles; but the area over which it can be profitably worked at present is much less (p. 213).

Then follows a description of the Caythorpe Ironstone; the Ironstone of Holwell, Leicestershire; the Oxfordshire Ironstone; with sundry smaller deposits.

The Northamptonshire Ironstone is next described, with its interesting series of fossil-remains, made known by the labours of the late Mr. Samuel Sharpe, F.G.S., formerly of Dallington Hall, near Northampton. From thence the author takes us to Seend, in Wiltshire, etc.; and lastly to the Iron-ore deposits of Ireland.

The practical and commercial parts of Iron-ore industry occupy parts iii. and iv., but space does not permit us to dwell upon them here.

We have said sufficient to show that Mr. Kendall is a thoroughly practical, painstaking, careful and efficient guide to the student (whether young or old) who desires further information on the mode of occurrence and places where Iron-ore industries are being carried on, and he may be trusted to guide aright.

Every section is accompanied by a list of all the more important authorities who have written upon the special branch of the subject, and the diagrams and tables are clear and carefully executed.

The book is sure to make its way with practical miners and students as a handy book of reference.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 7th, 1893. — W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1.—"The Bajocian of the Sherborne District: its relations to Subjacent and Superjacent Deposits." By S. S. Buckman, Esq., F.G.S.

This paper is partly the result of excavations made by Mr. Hudleston, F.R.S., and the author at Sherborne, to determine the position of the so-called '*Sowerbyi*-zone.'

The author uses the term 'Bajocian' in a merely conventional sense to denote the lower beds of what has been called 'Upper part of the Inferior Oolite.' He introduces a term emar (ἦμαρ) as a chronological subdivision of an 'age,' and considers the beds dealt with in the paper to have been deposited during 12 emata, which he calls, in descending order, *fuscum*, *zigzag*, *Truellii*, *Garantianum*, *niortense*, *Humphriesianum*, *Sauzei*, *Witchellia* sp., *discites*, *concavum*, *bradfordense*, and *Murchisonæ*.

A line from Stoford, Somerset, through North Dorset to Milborne Wick, Somerset, is the base-line of the district reviewed. Seventeen sections of places close to this line are given to show the relations of the beds, with the different amounts of strata deposited during successive emata, and during the same emar at different places. By means of Tables he shows that the area of maximum accumulation receded eastwards in the earlier emata, and then proceeded westwards during the later emata. A similar and corresponding faunal recession and progression is pointed out, though the faunal headquarters always remain west of the great accumulation of deposit. Adding the various maximum deposits together, the author finds as much as 130 feet of strata deposited during the twelve emata, = (practically) the 'Inferior Oolite of Dorset.' This is a far greater thickness than has hitherto been allowed to beds of this age in the district, but the fault lay partly in incorrect correlation.

The Dorset strata are correlated with strata in other districts—namely, with those of Dundry and Leckhampton Hills in this country. Of these the author gives sections, pointing out the emata during which the strata of those localities were deposited, and making some alterations in their correlation.

Passing to Württemberg, the author shows that the equivalent of Waagen's *Sowerbyi*-zone is exactly represented at Sherborne. Returning to Normandy, the author compares his results with the recent work done by Munier-Chalmas, who in some respects has made an even more detailed subdivision of the strata. In a Table he shows the correspondence between his divisions for Dorset and those of Munier-Chalmas in Normandy and Haug in Southern France.

2. "On Raised Beaches and Rolled Stones at High Levels in Jersey." By Andrew Dunlop, M.D., F.G.S.

In this paper the Author gives some account of the higher raised beaches examined by him on the south-eastern and eastern coast, but probably found in other parts of the island also, as indicated by the existence of rolled stones, etc. These beaches seem to prove submergence (in the case of that at South Hill, to a depth of at least 130 feet below the present level) at the end of the 'first glacier period.'

The brick-clay often lying on raised beach, and containing pebbles, has been compared to loess by the author. He believes that Prof. Prestwich's theory of sudden and rapid upheaval, with a resulting tumultous sweep of water, may be applied to Jersey; but also, if the sinking took place at the end of the Glacial Period, the peculiar conditions produced by melting ice may have played their part in producing the brick-clays.

Subsequent upheaval above the present sea-level is indicated by submerged forests, sometimes lying on the brick-clay.

No fossils have hitherto been found in the raised beaches; but a bone of *Bos primigenius* (?) has been extracted from the brick-clay.

II.—June 21st, 1893.—Dr. H. Woodward, F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "On composite Dykes in Arran." By Prof. J. W. Judd, F.R.S., V.P.G.S.

It is proposed to apply the term 'composite dyke' to any fissure which contains two or more distinct varieties of igneous rock, differing from one another in chemical composition or mineralogical constitution. Such dykes, it is shown, fall into two classes:—

(A) Dykes in which differentiation has evidently taken place in the materials after their injection, as in the examples described by Dr. Lawson in Canada and by Prof. Vogt in Norway.

(B) Dykes in which we have evidence of the re-opening of the fissure after its first injection and the introduction of materials of totally different composition. It is this class of dykes of which we find such interesting illustrations in Arran.

These Arran dykes belong to the latest volcanic eruptions of the British Islands; their analogues are found alike in the South of Scotland, and in the North of England and of Ireland. They are the infilled fissures along which sporadic volcanic outbursts took place after the extinction of the great volcanoes of the Inner Hebrides. The subaerial products of these later, and, for the most part, insignificant volcanic eruptions, have been all swept away by denudation, except at Beinn Hiant and the Sgúr of Eigg.

The materials filling these dykes belong to two totally different classes,—one distinctly basic, with about 55 per cent. of silica; and the other markedly acid in composition, with from 65 to 75 per cent. of silica. The basic rock is an augite-andesite, which passes sometimes into an intersertal and occasionally into an ophitic dolerite (tholeite and diabase); the glass of this rock shows a great tendency to separate from the phenocrysts. The acid rock is often a highly vitreous material ('pitchstone' or 'pitchstone-porphyry') which

by devitrification passes into various forms of felsite and quartz-felsite. These rocks, if we class them according to the nature of the porphyritic minerals they contain, fall into the several groups of vitrophyric and trachytoid lavas, to which the terms pantellerite, quartz-pantellerite, rhyolite, andesite, and dacite have been applied. The glassy groundmass in the whole of these rocks, however, is always abundant, and its characters are remarkably uniform however much the phenocrysts may vary.

An admirable type of the Arran composite dykes is found at Cir Mhor; this dyke traverses the granite, and has been excellently described by Ramsay and Bryce. The sides of the dyke are composed of augite-andesite, having a specific gravity of 2·71 and a silica percentage of 56; the centre of the dyke consists of a quartz-pantellerite with glassy base ('pitchstone-porphyry') passing into various stony varieties: this acid rock has a specific gravity of 2·36, and contains from 72 to 75 per cent. of silica, it is rich in soda as well as potash, and yields much water. The acid and basic rocks are strikingly contrasted with one another, alike in the characters of all their porphyritic crystals and of their vitreous bases. The acid rocks, however, contain a few crystals which have evidently been derived from the basic rock.

There is one fact with respect to the acid rock of the Cir Mhor dyke, to which attention is now called for the first time. Hyalite, the clear form of opal, occurs in it as a rock-constituent, and forms globules made up of several concentric layers which envelop the grains of quartz, are moulded on the angles of the felspar-crystals, and sometimes form independent segregations, with nuclei of tridymite-crystals. The identity of this interesting mineral has been established, not only by its optical properties, but by various microchemical tests.

On the shore and in the cliffs at Tormore, on the west coast of Arran, there occurs a remarkable plexus of dykes, many of which supply striking illustrations of our second class of 'composite dykes.' The locality was first described by Jameson, and some of the dykes have since been noticed by Allport, Zirkel, and other authors. In these composite dykes both the basic and the acid rocks are present; but while in some cases the acid rock was clearly introduced after the basic, in others the order of ejection of the two materials was reversed. In some instances, the plane of weakness along which the opening and re-injection of the dyke took place follows its central line; at other times it is at the side of the dyke; and occasionally it traverses the dyke-mass in a sinuous manner. The younger rock often contains numerous crystals derived from the older one, and these often show much alteration from the action of the magma in which they have been caught up. It is evident that the interval between the first and second injection of these dykes was sufficiently long to allow of the complete consolidation of the older rock

In conclusion, it is pointed out that, while the peculiarities of the first class of composite dykes can be accounted for by selective crystallization and liquation going on within the magma which has

been injected into the dyke, no such explanation is sufficient in the case of the composite dykes of the second class, to which the examples cited from Arran belong.

That the association of two totally different rocks in the same dyke is not accidental, the numerous and varied examples at Tormore sufficiently prove. Where, as in these cases, we find that there is the greatest dissimilarity between both the crystals and the glassy groundmass of the two rocks, it is clear that the differentiation has taken place in the magma, prior to its injection into the dykes, and before the work of crystallization had commenced. The physical causes which have been suggested to account for such differentiation in a fluid mixture of silicates are discussed.

2. "Notes on an Intrusive Sheet of Diabase and Associated Rocks at Robin Hood, near Bassenthwaite." By J. Postlethwaite, Esq., F.G.S.

The positions of the outcrops of the igneous rock are described, and a grit-band is recorded as running parallel to the diabase. The diabase, and vein-stuff associated with it, have furnished antimony, lead, copper, and arsenic; and the same ores, with the exception of the last two, are also found in minute grains in the grit. Analyses of the grit and diabase, made by Messrs. Hellon and Brockbank, are given. Prof. Bonney has examined slides submitted by the author, and has allowed the use of his notes in the paper. The igneous rock has produced slight metamorphism in the surrounding rocks of the Skiddaw Slates.

3. "On Two Dinosaurian Teeth from Aylesbury." By R. Lydekker, Esq., B.A., F.G.S.

Two teeth from the neighbourhood of Aylesbury, believed to be of Portlandian age, may be referred to the same species as is a tooth figured by De La Moussay from the Portlandian of Boulogne. The Aylesbury teeth are described in the paper, and the nature of the animal which possessed them is discussed.

4. "On a New Plesiosaur from the Waipara River, New Zealand." By Capt. F. W. Hutton, F.R.S., F.G.S.

This specimen was shortly described by Sir James Hector in 1873. The author considers it more prudent to follow Mr. Lydekker in referring all the known New Zealand Cretaceous Sauropterygians with which he is acquainted to Leidy's genus *Cimoliosaurus*, and he therefore describes this form as a new species of that genus.

5. "Observations on the Affinities of the Genus *Astrocœnia*." By Robert F. Tomes, Esq. F.G.S.

Researches recently made by the author relative to the structure of certain undoubted *Astrocœniæ* of the Gosau beds, having for their primary object the better understanding of the supposed species of the genus obtained from the Glamorganshire conglomerate, have been productive of results which will render a complete modification in the classificatory position of the genus imperative.

The author gives a new definition of the genus, in which he does not at present include any species of an earlier date than the Cretaceous period, all the so-called Jurassic *Astrocœniæ* being referable to other and quite distinct genera.

6. "Description of a new Genus of *Madreporaria* from the Sutton Stone of South Wales." By Robert F. Tomes, Esq., F.G.S.

In the Quarterly Journal for 1885 is a detailed description of a coral from the Sutton Stone named *Astrocœnia gibbosa*. This specimen is not the type of the species, and a re-examination of it by the author has proved that it is not an *Astrocœnia*. Two other specimens have also been examined, and as a result of examination of the three the author is enabled to found a new genus *Styloseris*, of which a diagnosis is given, and the specific name *gibbosa* is retained for this, the only known species. The genus will take its place near *Clausastræa*, from which it differs by possessing a well developed columella and increasing by both fissiparity and gemmation.

7. "Study of the Dykes of Hope, Idaho." By Herbert R. Wood, Esq. Communicated by the President.

In this paper a description of the geographical distribution and characters of acid and basic dykes traversing slates and quartzites along the northern shore of Lake Pend'Oreille, Idaho, is accompanied by notes on the glaciation of the area. A brief description of the microscopic features of the igneous rocks is appended.

8. "The Rise and Fall of Lake Tanganyika." By Dr. Robert Sieger. Communicated by the President.

The author refers to Mr. Carson's paper on the same subject in the Society's Journal for 1892. He himself believes the oscillation of level to be analogous to variations reported as occurring in other African lakes, and to be due to climatic change. He brings forward evidence in favour of the coincidence of change of level and climatic change, but does not believe that his views are by any means contradictory to those of Mr. Carson, for the phenomena may be explained by a combination of the influences of climate with those of mechanical agencies.

9. "On Cheilostomatous Bryozoa from the Middle Lias." By Edwin A. Walford, Esq., F.G.S.

The author describes some forms of bryozoa from the *spinatus*-zone of the Middle Lias near Banbury, some of which had previously been classed with the Cyclostomata. The new material not only shows the opercular aperture but the opercula *in situ*, together with appendages and supra-oral ovicells characteristic of the Cheilostomata. In addition he has also found giant cells (cistern cells) of form quite dissimilar from the ordinary zoœcia and probably reproductive. He cites M. Jules Haime as having described in his magnificent monograph somewhat similar cells from the Inferior Oolite; and in the Oxfordshire Great Oolite Bryozoa Mr. Walford has found cistern-cells like the Lias species on some colonies like *Diastoporæ*. He contends that it is merely the acquisition of very well-preserved material which is needed to show the necessity of removal of many such species to the Cheilostomata. The name *Cisternophora* is suggested for the genus, of which several forms are described.

The next Ordinary Meeting of the Society will be held on Wednesday, November 8th, 1893.

AN UNFAMILIAR RAILWAY DANGER.

Sir,—In a short paper by Mr. Griesbach, C.I.E., of the Geological Survey of India, which appears in the Records of that Survey for May, 1893,[1] we learn that both lines of rails of the frontier section of the North-Western Railway, near the Station of Sanzal, in the neighbourhood of the Kójak Range, in Balúchistán, became violently distorted where crossed obliquely by a line of fissure which was caused by the earthquake of the 20th of December last. The first and most severe shock occurred at 5.40 a.m., but several others recurred at frequent intervals during that day and the two following. Photogravеur illustrations of the scene showing the deflection of the rails, as well as a plan to scale, are given, from which it appears that the curvature of both pairs of rails, within a length of from 30 to 40 feet, shifted them more than the width of the track in each case, the curves being so sharp that any train passing along the lines in the dark, or without the occurrence being noticed or looked for, must have been wrecked. Buildings suffer more from earthquakes than Railways, still, these earth-movements are not so uncommon that Railway Companies should neglect the hint given by the occurrence.

A. B. W.

OBITUARY.

THE REV. HENRY HUGH HIGGINS, M.A.

Born 28 January, 1814; Died 2 July, 1893.

The City of Liverpool has sustained a great loss in its intellectual life, by the death of the Rev. H. H. Higgins, M.A., who for more than forty years has devoted himself to the advancement of Natural Science in the midst of one of the busiest communities in England.

Born at Turvey Abbey, Beds, on January 28, 1814, he entered Corpus Christi College, Cambridge, in 1833, and took his B.A. degree in 1836. He was admitted to priest's orders in 1839, and devoted four years to clerical duty in the town of Wolverhampton, proceeding in the following year to Shrewsbury. Mr. Higgins came to reside in Liverpool in 1842, and occupied himself with more congenial educational work, being made Inspector of the Schools of the Church of England School Society, a position which he resigned in 1848, though, as Hon. Secretary, and afterwards Hon. Treasurer, he retained connection with the Society. After performing other church duties, he was appointed Chaplain to the County Asylum, Rainhill, in 1853, which post he continued to hold until 1886. A long Eastern tour through the Holy Land and Egypt was undertaken in 1848, and described in a course of six lectures given at the Liverpool Collegiate Institution, the proceeds of which—amounting to £300—Mr. Higgins generously gave to the School Society. In 1876 he accompanied Mr. Reginald Cholmondeley in his steam yacht, the "Argo," on a voyage to the West Indies, which Mr. Higgins has charmingly described in a small 12mo. volume entitled "Notes by a Field Naturalist in the Western Tropics." Valuable collections of natural history specimens, now interspersed

[1] This paper has only just come to hand since the writing of Mr. C. Davison's article, see *ante* pp. 356–360.—Edit. Geol. Mag.

in the series exhibited in the Liverpool Free Public Museum, resulted from the voyage. This Museum is largely indebted to Mr. Higgins's labours. For a long series of years he has acted as Chairman of the Museum Sub-Committee of Management, and he has besides devoted many hours weekly to the classification and arrangement of the collections in the possession of the city. In connection with this institution Mr. Higgins is the author of three useful handbooks, viz.—a "Synopsis of the Invertebrata," a "Museum Memorandum Book," and a popular pamphlet entitled "Museum Talk," of which more than 25,000 copies have been sold at a nominal price in the Museum buildings. He has also published an essay on "Museums of Natural History" (contributed originally to the Literary and Philosophical Society of Liverpool, which is replete with practical suggestions on museum management and appliances. "The most important function of a museum," states our author in this work, is not so much to instruct as to win and encourage minds to get themselves instructed through habits of observation." One of the most valuable collections in the Museum is a fine series of Coal Measure fossils, collected by Mr. Higgins himself from a railway cutting at Ravenhead, near St. Helens. In 1880 he was fortunate in securing for the Museum a numerous series of Cirripedes collected in the "Beagle" by Charles Darwin. These were duplicates remaining after Mr. Darwin had (as he states in a letter to Mr. Higgins) made the British Museum collection as perfect as he could. The system of circulating boxes of museum specimens for use in schools was also originated by him. On more than one occasion Mr. Higgins has received from admirers of his work testimonials showing how greatly his labours have been appreciated.

Mr. Higgins founded, in the year 1860, the Liverpool Naturalists' Field Club, of which he was President to the last; and he has also occupied the presidential chairs of the Literary and Philosophical and Microscopical Societies of Liverpool. His contributions to the published "Transactions" of these Societies, besides those of other similar associations, have been exceedingly numerous. They will be found conveniently collected in three 8vo. volumes, under the title of "Opuscula," in the Free Public Library of Liverpool. The papers contained in these volumes range in date from 1855 to 1887, and deal with a variety of scientific subjects in a light and pleasing, yet instructive manner. In all his writings, Mr. Higgins is a true exponent of the "poetry of science," which is far too often neglected in our modern haste for the rapid acquirement of knowledge—so characteristic a feature of the age in which we live.

With him originated the idea of sending out preserved specimens of various classes of creatures to form the subjects of lessons in elementary zoology and botany for schools. This commenced in 1884, and in the interval, the technical education scheme having been introduced, these specimens have been found exceedingly useful, especially as every one of them bears attached a few short notes indicating the outline of a lesson which the teacher has to prepare. Proceeding further in this direction, Mr. Higgins quite recently projected a popular mineral collection to show how things

dug out of the earth are rendered useful to man by being passed through various processes. Thus iron was to be seen in several stages, from the ore to the manufactured article. The introduction of mechanical models into the course of school lessons was also one of his ideas, and this was admirably carried out, notably by the "model clock" (made for him by Mr. George Eccles, clockmaker), which can be taken to pieces and put together again by the fingers, without the aid of tools. This clock is sent to the elementary schools whenever required, and when not so in use it stands in the vestibule of the Museum. He also strongly advocated the use of the lantern and limelight in illustrating lectures and lessons.

So deeply did he feel the importance of a museum as an institution which should be extended and rendered as complete and useful as possible, that he gladly took part in organising the Museums' Association, which held its first regular meeting in Liverpool in June, 1890, and, having been chosen the first President, he delivered the inaugural address, in the course of which, after having dealt with the general subject of natural history museums and their appliances, he went on to speak of "The New Knowledge." "As members," he said, "of our museum fellowship we are bound to be more or less familiar with the scientific side of the new knowledge, and must have felt the magnitude of the revolution it has brought about. It has an equally potent moral side, from which I will ask you to consider an inference fraught with encouragement for the future. The new knowledge leads to the conclusion that the most exalted productions ever brought forth in poetry, philosophy, or science were not obtained otherwise than in the orderly course of results which had gone before. Shakespeare could not have lived 100 years before his time. His life was not a miracle, except as having its share in that ever-energising and enduring life-miracle in the presence of which we stand silent with bowed heads. Galileo, Bruno, had their times prepared for them, and in their turn prepared the way for Faraday, Agassiz, Darwin. Nor is there in our own days even the least indication of an approach to finality; gravitation, electricity, life are unknown essences. In biology some of the most illustrious discoveries still exhibit crudities and incompleteness removing them beyond a measurable distance from perfection. Were they, then, not discoveries? Assuredly they were; and in spite of all imperfections they are the glory of our times. But what we claim for our own knowledge we must grant to the attainments of our predecessors, admitting freely that there may be great good and even great glory in a very imperfect stage of knowledge, if it be that which is best fitted for its environments. This we have been slack in perceiving, because we have not realised how vast, how unique a thing has been the flow of knowledge from age to age. Take the knowledge of any age: it is a goal; it has been tended towards and reached by the efforts and successes of many former ages: it is a terminus, long forecasted, towards which the steps of followers have been unconsciously directed, rendering it more and more accessible as generations came and went." So much interest did Mr. Higgins manifest in the success of the Museums' Association that he con-

stantly attended its meetings, and it had been arranged that he and Mr. Paden, the acting curator at the William Brown Museum, should proceed to London on the 3rd July to attend a meeting of the Association there, commencing on Monday evening. This journey was agreed upon no later than on the 1st July, when, after listening to Mr. Best's organ recital, Mr. Higgins crossed over to the Museum, as was his usual custom almost daily.

The officials and employés at the Museum and Free Library received the news of his death with profound regret. Not being a member of the City Council, he could not be elected chairman of the Library, Museum, and Arts Committee, but some years ago he was appointed Chairman of the Sub-Committee of the Museum and Mayer Collection, and continued in that office till the last. It is almost needless to say that his literary attainments were of a high order, and that he was one of the most valued members of the Library Committee when books new or old came to be selected.

Mr. Higgins, who was in his eightieth year, had been in his usual health on Sunday, 2nd July, and proceeded to his library, as was his wont, in the evening, where his retirement was not broken, and was permitted to remain undisturbed for some time, but on his study being entered about nine o'clock Mr. Higgins was found by one of his sons sitting at his writing-desk, surrounded as usual with his books and papers, but quite dead. The circumstances of his death seemed, one would think, an appropriate close to a life the remarkable industry and activity of which has aided so largely in the advance of scientific progress and educational culture and has left no time for idleness. It was known to the family that he had intended to proceed on Monday, 3rd July, to London, to attend the Meeting of the Museums' Association, at which he had undertaken to read a paper entitled "On a Public Museum Series of Minerals arranged in aid of Technical Education." The manuscript found on his writing-desk immediately in front of him showed that he had been busily engaged on that very work. Several folios of it had been written, and its sudden stoppage in the middle of a word indicated that the attack had proved at once fatal.

With the Literary and Philosophical Society of Liverpool Mr. Higgins had been connected for forty-six years, and he had twice filled office as its President.

Mr. Higgins was also intimately identified with the Naturalist's Field-club, another society connected with the Royal Institution, and he had been its President for many years, and a constant attendant at the field meetings. He was also identified with the Microscopical, and other scientific societies held in Liverpool.

On the death, in 1885, of his brother, Charles Longuet Higgins, of Turvey Abbey (the "Good Layman" in Dean Burgon's "Lives of Twelve Good Men"), Mr. Higgins succeeded to the manor of Turvey and the family estates in Bedfordshire and Buckinghamshire.

Although he will be long remembered and much missed in connection with the societies already named, the work which he accomplished in connection with the Free Library and Museum, on

the committee of which he was a member for about thirty-three years, will probably in future years be regarded as the chief monument to his memory. His labours in reference to the Museum commenced really about seven years before he became a member of the committee, in November, 1859, as a representative of the Derby Trustees, his scientific knowledge, of which the late Sir James Picton had a very high opinion, pointing him out as probably the best-equipped gentleman in Liverpool to assist by his advice in extending the scope of the Institution, which was then at its commencement, and which has since become so famous. His labour in the Liverpool Museum for the past forty years may therefore be truly described as a labour of love. In the classification and arrangement of the specimens he took an active part in conjunction with the chief curator, the late Mr. T. J. Moore, the two officials making a general division of the work, Mr. Moore attending chiefly to the vertebrates, and Mr. Higgins to the invertebrates, each rendering the other the most ready assistance, and working in perfect harmony to the last, Mr. Moore having passed away only a few months ago. With an eye to the practical as well as the strictly scientific uses of the Museum, Mr. Higgins conceived the idea of exhibiting the specimens in so simple a manner that people of ordinary education could appreciate them, and to that end he compiled the well-known little book entitled "Museum Talk about Animals which have no Bones," and which was intended and has been extensively used as a "Visitors' Companion" to the Museum. That the pamphlet has become popular may be gathered from the fact that 36,000 copies have been issued in six editions.

Rarely could anyone retain, as Mr. Higgins did, for nearly eighty years, that earnest craving for increased scientific knowledge, combined with a child-like simplicity and sweetness of disposition which endeared him to his friends and attracted all young people to him from far and wide.

He was a keen musician, and his love of harmony pervaded all his scientific pursuits, and added a charm to his home-life, and to the wider circle of those who knew and appreciated him for his many personal merits, as well as for his devotion to the public service.

ERRATA: GEOLOGICAL MAGAZINE, JULY, 1893.

Readers are requested to make the following corrections in Prof. V. Ball's article on "Barren Island."

p. 290. Note 1., for *Rhyticiros*, read *Rhyticeros*.
p. 291. line 10, for "Prince," read "Prine."

In *re* "New Classifications of the Brachiopoda," GEOLOGICAL MAGAZINE, July, p. 318, third line from bottom, for *Neotremata*, read *Protremata*.

The *Telotremata* originated from the pentameroids of the *Protremata*, as is correctly indicated by Mr. Schuchert on his Table V. and p. 145, "American Geologist," vol. xi. No. 3, while on a subsequent page (147) he states "The *Telotremata* had their origin in the *Neotremata*"! The first statements are correct, but the fact is the ordinal characters converge the farther we go back in geological times, and what better proof can we have of the evolution of the Brachiopoda? Mr. Chas. Schuchert is now attached to the National Museum, Washington, D.C., U.S.A.

AGNES CRANE.

On p. 336, line 6 from bottom, for "Gygomatic," read "Zygomatic."